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OF THE
AMERICAN WATER WORKS ASSOCIATION

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OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

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COMMENTS

NEWARK'S EXPERIENCE IN RELOCATING POORLY SET METERS

In the course of a study of the most efficient use of all available labor which war-time conditions made highly important, the water department of Newark, N. J., became convinced that decided improvements in reading meters were practicable. The older members of the Association will recall the amusement which, years ago, greeted the statements occasionally made about a phenomenal number of readings per day by Mr. Charles' men, and their astonishment when they learned that such a record was actually made during a visit to the plant in question by two of our past-presidents. The achievement was possible because the meters were located so as to make reading them exceptionally easy and rapid, something that never occurred to those who felt that Mr. Charles' system of scoring should be sent to the shop to have its over-registration remedied. In Newark, experience has shown a remarkable gain in the efficiency of the meter reading staff by relocating meters hitherto difficult of access. This relocation has been carried out so fully that there are only about a dozen meters in the city now which are not readily reached by the reader.

The work was done by first obtaining from the readers as they made their regular rounds a list of the inaccessible meters. Then inspectors visited them and studied the best remedy for each of

these cases. The owner was then notified to make the change and the reason for it was explained. As the purpose of the water department was to secure the maximum improvement as quickly as possible, cases of serious opposition to making the relocation were given little attention until the first campaign was well along toward what it was foreseen would be a satisfactory conclusion. The strong objectors then received attention, and the changes were brought about by using such measures as seemed best fitted to the conditions of each case. The practical outcome of the work has been an increase of about fifty per cent in the efficiency of the meter reading staff, a result of decided importance in a city of nearly half a million inhabitants. The result also shows conclusively the importance of locating meters originally in the most accessible place available, something which it is thought will be of interest to water departments generally. John W. Judson, chief accountant for the Newark Water Department, has been very energetic in pushing the work of relocating meters and in seeing that new meters are satisfactorily placed.

There is one feature of the work about which there exists a difference of opinion, and the views of the members on it will be received gladly in Newark. This is the proper location of a meter for a factory service. Some hold that the best place is outdoors in a well-built, easily reached pit. Others hold that the meter should be in the factory building. This is now a subject of such importance in Newark, and may become so elsewhere, that members who have had experience showing any special advantage or disadvantage in either location are asked to send reports of their experience to the editor of the Journal, in order that they may be published in the Journal in addition to being communicated promptly to the writer of these notes.

Morris R. Sherrerd.

THE SUPERVISING ENGINEERS' TROUBLES IN CANTONMENT CONSTRUCTION

The paper on the water works of Camp McClellan which Mr. Scharff contributes to this number of the Journal affords an opportunity to make some long overdue comments on the troubles experienced by the supervising engineers who had local charge of the engineering features of the construction of the military camps and

cantonments in the summer of 1917. Their work has not been given the public recognition it has deserved; the very conditions of it have prevented such recognition. In May, June and July, 1917, there was assembled at Washington the most competent group of specialists which ever met to consider municipal problems. Working under tremendous difficulties and without facilities not supplied by themselves as a rule, these engineers planned a typical military city and laid down the general principles to be followed in providing it with the needful utilities. These general plans and sets of governing regulations were then sent out to the supervising engineer of each camp or cantonment, and it was the trying task of that engineer to design his city to conform as closely to the typical plan as the topography of the site and the various governing principles would permit. Headquarters acted essentially as a consulting engineer, as a staff advisor, while the supervising engineer was the actual planner and superintendent, performing a line function.

It has been said that the specialists advising the Construction Division or acting as officers in it worked under tremendous pressure. Just so far as they could foresee a question likely to arise in the field they endeavored to answer it, so as to reduce to a minimum the need for reference to headquarters from the field. Yet despite all this care, although the regulations governing field work were scrutinized by a number of the ablest, most experienced specialists in the country, they were not wholly clear. In the basic matter of the per capita water supply to be provided, Mr. Scharff encountered lack of clearness in the rules, as he points out at the beginning of his paper. This is not mentioned here, nor does Mr. Scharff mention it in his paper, in the spirit of captious criticism, but rather as a guide for us in future work. This recent tremendous drain on our lives and resources will not yield its greatest returns unless we take to heart the little details as well as the big things which the war teaches. One of these little things is the importance of perfect clearness and preciseness in instructions to field officers, and out of the experience of the supervising engineers in camp and cantonment construction with the regulations of the Construction Division it should be possible to develop a code of field instructions of substantial value to the engineering profession and invaluable to the War Department.

When the supervising engineer reached the camp site he was charged with the duty of constructing a city for 20,000 to 45,000 population in about three months. The clearing of the site of one of

these great areas would usually occupy about that period under ordinary construction conditions. Time was the paramount consideration; a day was worth more than a month during peace times, and the supervising engineer was the man responsible for saving that day, so far as engineering work was concerned. The time factor introduced peculiar difficulties that only the supervising engineer himself could realize fully, for frequently this insistent call for the highest speed possible changed the usual order of precedence of the elements governing the choice of plans and methods, and it needed a versatile as well as clear-thinking mind to adopt suddenly new points of view, as in selecting a source of water supply for Camp McClellan and in choosing pipe sizes and the location of the supply main. Attention is called particularly to Mr. Scharff's statement of the pipe sizes which he was forced to use to meet his time schedules.

It was not alone in designing and constructing the camps that the ingenuity and nerve of the supervising engineer were tested to the full. Every superintendent should consider what it meant to operate a booster pumping station as was done at Camp McClellan during August and September, while carrying the enormous detail work of finishing the construction of the city. Such operation is a story of real interest in itself, yet it was just an incident, a mosquito bite, in the life of the supervising engineers at these camps during those strenuous times. How these men and their assistants accomplished what they did will probably never be told, but it is worth telling as the "inside story," the real story, of how our troops found shelter in these great military cities when they arrived at them.

The writer of these comments became familiar with the water works of the camps and cantonments after the supervising engineers had finished their work. He has been in general charge of their operation and has been deeply impressed by the intricacy of the problems which these field engineers had to solve on the spur of the moment, and by the success of their work. The combined water supply and sewage problems at Camp McClellan were even more than ordinarily difficult, and it is a pleasure as well as a duty to bear witness to the efficient manner in which the problems were solved at this camp.

George A. Johnson.

A POSSIBLE FIELD FOR WORK BY THE SECTIONS

There was an unusually interesting incident of the annual meeting of the Iowa Section at Mason City in October. This city has been growing rapidly and has pressing need of the solution of several water supply problems. It possesses a keen, active Chamber of Commerce, like so many other thriving committees in the Central States. Such a body is usually representative of the substantial taxpayers of the city, who naturally wish to have their tax money spent so as to produce the largest useful returns. One of the largest individual investments of a city is usually that in its system of water works. Such a plant is essentially a business proposition, and should be administered in accordance with the best business principles. Consequently, the board of directors of the Chamber of Commerce of Mason City decided that the presence of a large number of water works managers as their guests afforded an opportunity to learn something about this particular kind of business by discussing some of its features with the visitors. Whether the directors learned anything of value to them, is for them to say, but the incident in itself suggests an important thought.

The various sections of the Association comprise men who are devoting their time and energies to the most important utility business in a city. It is a business requiring technical knowledge to ensure a supply that is safe to use and to provide a plant which will furnish that supply at the minimum price consistent with sound financial administration. It is also a big retail business, probably the biggest in the city, which demands good business methods of management. In short, the average water works proposition, presented properly to a Chamber of Commerce, should appear at once to such a body as something directly in its line, something to cherish and foster, to protect against injurious political interference and short sighted, ill-conceived policies and to back up with the collective weight of the business men of the community when it needs such help. The questions naturally arise: Have we tried to secure the support of these influential semi-public organizations? If we have not, how can we do so?

The writer has not given this subject enough thought to suggest an answer to either question. But he is convinced, in view of the influence that has been exerted upon public affairs by the Boston Society of Civil Engineers, the Cleveland Engineers' Society, the Engi-

neering Association of Nashville and the Iowa Engineering Society, to mention only a few instances, that the local Sections, backed by the parent body, can give a most helpful service in awakening a general appreciation of the financial and administrative importance of water works. If that recognition can be won, if water works problems can be left to water works specialists for solution, as a matter of course, the country will take a long step forward in the administration of public business. It is good to have the press with one, but it is best to have the hearty backing of the substantial commercial interests of a community. That backing can probably be obtained in many instances by demonstrating to these local Chambers of Commerce the importance of the water supply business which furnishes them with one of the essentials for their daily life, as well as protection for their property and livelihood.

JACK J. HINMAN, JR.

STANDARD SPECIFICATIONS FOR WATER METERS

At the annual convention of the New England Water Works Association held in September, 1916, a paper was presented by R. J. Thomas entitled "A suggestion that the Association appoint a committee to prepare standard specifications for water meters." In this paper Mr. Thomas pointed out that there was then no specification available under which meters could satisfactorily be purchased on open competition, and attention was directed to the inadequacy of the comparatively few specifications which had been used up to that time. As a result of this paper a resolution was adopted which read as follows:

> That the association appoint a committee to investigate the desirability of formulating meter specifications, and to standardize the nomenclature of meter parts.

Pursuant to this resolution a committee of eight was appointed by the New England Water Works Association, Charles W. Sherman, Boston, Mass., being chairman, and the writer one of the members.

Up to the termination of the World War very little was accomplished in the preparation of such specifications. Shortly after the armistice was signed, James A. Tilden, vice-president and general manager of the Hersey Meter Manufacturing Company, advised that the meter manufacturers' exchange, which includes all

but three of the meter companies, had undertaken to investigate this subject and prepare as speedily as possible specifications which would meet the views of the manufacturers, and also would be drawn with a view to safeguarding the interests of the purchasers of meters. After a great amount of work had been done and many meetings and discussions had been held, Mr. Tilden was able to present in October, 1919, tentative specifications for disc and current meters.

These specifications furnish, in the writer's opinion, a very promising outlook for an ultimate agreement between the manufacturers and the New England Water Works Association committee on the more important and controlling items in the design, manufacture and performance of meters. The manufacturers are most anxious that joint action on this important subject should be taken by both the New England and the American Water Works Associations. The writer has requested President Davis to appoint a committee to represent this Association, and believes such a committee will shortly be named.

The desirability of there being one standard specification rather than two for water works equipment is universally acknowledged. It is now probable that by the time we meet in Montreal early next summer the members of the Association will have an opportunity to discuss the proposed specifications and aid in the formulation of the clauses that will express the views of the majority of the members.

W. W. Brush.

THE STATUS OF OZONE IN THE TREATMENT OF WATER

On another page of this issue of the Journal the use of ozone as a disinfectant in the purification of water is explained by Joseph W. Ellms in his characteristic clear manner. The paper deals carefully, very carefully, with the possibilities of ozone in water supply service. It points out the technical difficulties attending its successful use as a reliable germicidal agent, but it mentions only casually its cost in practical water treatment. It is these two factors which, up to the present time, have prevented any general use of ozone for this purpose.

It is possible that ozone will become a more useful agent in our work than it is today. Everybody whose aim is to insure the delivery of wholesome water to our cities at minimum cost will welcome every advance in the technique of producing and using ozone

which will reduce the delay in the arrival of the day when it can be considered a really useful, practical agent. But that day will not come, apparently, until two distinct, unrelated problems in science are solved. The first of these is the continuous production of the gas at lower cost than it is made today. The second problem is presented by the needed development of an absolutely certain, complete and continuous mixing of the ozone and water. Every atom of water must be brought into direct contact with the ozonized air in the large-scale operations of practical water supply. The successful small-scale operations of the laboratory are not always certain proof of the practical, large-scale value of a delicate chemical process.

The writer has followed the development of ozonization for twenty years or so and has found it most interesting, even alluring, but up to date it is experimental, not practical. He cannot share fully the optimism of Mr. Ellms about this method of treatment. After years of experiment conducted with all the technical and financial resources of great American and European electrical manufacturing companies and after many private studies by consulting specialists, no substantial progress has been made for a good many years in the practical treatment of large quantities of water. A new discovery may change this condition at any time, but there is no hint of such a discovery heard today in scientific and technical circles. The very fact that the manufacturers of the apparatus which would be used in this method of disinfection have apparently abandoned it for the time being as a desirable field for exploitation is significant.

GEORGE A. JOHNSON.

QUESTIONS BEFORE THE HOUSE

At the Buffalo convention, a number of topics were brought up for discussion, but for one reason or another the amount of information elicited was meager. Many members of the Association can contribute notes on these subjects which will prove of material help to those who have asked for such statements. The Publication Committee therefore requests the members to send to the editor of the JOURNAL an outline of their experience in the following matters, in order that fairly complete data on them may be compiled and published at an early date:

1. How may leaks due to cracks in the bottom of a concrete reservoir be stopped?

A method which D. A. Reed reported as successful is to cut a groove, half an inch wide and about three-fourths of an inch deep, along the crack with a chisel, and then calk the groove with hemp and asphaltum. Let every person who has attempted such repairs, with successful or unsuccessful results, report his experience to the JOURNAL's editor, in order that this really important feature of maintenance work may be properly covered in the Association's records.

2. Where foot valves on the suction pipes of centrifugal pumps are broken by water hammer when the pump stops, what remedy has proved successful?

At the Brantford water works, David L. Webster obtained relief, after losing three foot valves in a very short time, by placing multiport check valves on the discharge pipes. The subject is an important one, for accidents of this nature are of frequent occurrence. Let the editor of the JOURNAL know about such accidents, in order that data concerning them may be compiled, and let him know how the trouble was remedied.

3. What experience have members had with electrolysis where electric light companies ground alternating current wires on water services? How were the grounds made, what was the electric distribution system, and how was the electrolysis manifested?

The electrical experts say that theoretically there is no danger of electrolysis where alternating currents are used, but there have been about a dozen cases of it at Cooperstown, Pa., according to Homer C. Crawford, and a quite serious case where a meter was destroyed at Cortland, N. Y., according to G. T. Maxon. The subject is one which is attracting considerable attention over a wide section of the country, in spite of the pretty pictures drawn by electrical experts to show that there is no such thing. The accumulation of definite information of cases of electrolysis under such conditions will be a great help at this time, because if the electrical interests are right then water works managers have some new kind of trouble to study, and if they are wrong then it is high time for them to modify their assertions that alternating currents cannot harm metal conductors used as grounds.

4. How often should hydrants be inspected for frost? What rules have been found satisfactory in controlling the use of hydrants by persons not connected with the water department? Is there any method of setting hydrants that has been found particularly good in keeping down injury by frost?

Here are old questions, whose recurrence shows that the subject of frost action on hydrants and the control of the use of hydrants is as vital today as it was when the Association was a baby. Plainly there is an opportunity for the Publication Committee to render a real service by compiling the experience of the members on these topics, so that each member will please consider that the questions are addressed to him personally by the Publication Committee with an urgent request to report promptly and fully on them to the editor of the JOURNAL.

5. What is a satisfactory method of cleaning service pipes which become seriously clogged by incrustation or deposits?

Members who can contribute information on this subject are asked to explain in detail the construction of the appliances used and the method of handling them. This need of definite detailed information is shown by the following incident. The service pipe supplying the house of a member of the Publication Committee became clogged. The water is furnished by works managed by another member of the Publication Committee, who advised asking a local plumber to ream out the pipe. All the local plumbers said they never heard of such an operation and had no reamers. The manager of a well known water main cleaning company advised attaching a force pump to the house end of the service pipe and forcing a wad of tissue paper against the street pressure. The local plumbing talent threw up its several hands and said it simply could not be done, and the method was probably proposed as a joke. Now there are a number of published records of such work being done by both methods but nothing definite concerning just how to do it by either method or about the kind of deposits or incrustation which has been removed. Manifestly a soft deposit can be removed more easily than hard incrustation.

The attention of every member is called to these questions, for they are on subjects which the Buffalo convention was asked to discuss and failed to discuss fully. The Association was organized in order to enable such information to be gathered and disseminated in the easiest way. The JOURNAL is published for the purpose of giving to every member just such information, provided the membership will contribute a little time to send statements of their experience to its editor.

At the meeting of the New York Section on October 22 there was a discussion of the desirability of making the JOURNAL of more

help to the members by carrying a Question Box section in it, where questions by members and answers to these questions can be printed. It is a rule of experienced journalists not to start things that are not desired by readers. There is no proof in the hands of the Publication Committee now that such a section in the JOURNAL is desirable as a regular feature. But there is perfectly definite proof, which has just been stated, that information is desired by members on five subjects. If the members will furnish this information, and if other questions are submitted to the editor in order to obtain the information regarding them which the membership possesses, then the Publication Committee will be able to plan giving such service in the best practicable manner.

There is no doubt in the mind of the writer that the JOURNAL can be made a very useful medium for the exchange of practical information. Whether this is a practicable proposition will depend upon the members themselves, however, for they must take part in the work to the extent of sending their questions to the editor and in supplying him with a statement of their experience on subjects about which questions are asked. It is manifestly impracticable to send a letter of inquiry to each member about each question. The inquiries can only be made in the JOURNAL, like the five already referred to. Each member should consider that these questions are asked him individually and keep in mind that his coöperation in answering them means so much additional help in making our Association a truly mutual benefit organization.

JOHN M. GOODELL.

METER PRACTICES OF THE TERRE HAUTE WATER COMPANY

By Dow R. Gwinn[1]

Several papers in recent numbers of the Journal explaining features of the meter practice in several cities suggest that the methods of The Terre Haute Water Works Company may be of interest to the members. The conditions of water supply in the city are rendered rather unusual by the ease with which water may be obtained from the ground, so that there is a tendency rather more marked than usual to employ private supplies. This has made the problems of metering more sensitive to public opinion than is often the case and has also had its effect on the general subject of practicable rates. The supply is coagulated, settled, filtered, chlorinated and pumped, most of it being pumped twice, and it is therefore necessary as a business matter to collect revenue from all water that is furnished to consumers, whether they use or waste it. This can only be done satisfactorily by metering.

At first only large consumers like railways and industrial plants were metered. Then hotels, public buildings, livery stables, saloons and photographic galleries were metered, and after that stores and restaurants. Not much opposition was encountered to metering these consumers, but when the practice was extended to boarding and rooming houses there was an immediate vigorous public protest and the manager of the company was denounced at various indignation meetings of irate citizens. One reason for the outburst of feeling at this time was that there are two large educational institutions in the city and consequently a relatively large proportion of rooming and boarding houses.

Opposition of this kind had to be met vigorously in an educational way, so the company bought space in the newspaper advertising columns and published a series of "Water Talks" or statements

[1] President and Manager, The Terre Haute Water Works Company, Terre Haute, Ind. Discussion of this paper is requested and should be sent to the Editor.

of the reasons for the adoption of the company's policy. There was constant repetition of the sentence, "It is a good thing to pay for what you get," and it was interesting to hear some of the company's customers using the expression later, apparently unconscious that it was the company's slogan in its advertising campaign.

In 1914, with 44 per cent of the services metered, including practically every factory and business place, the average daily consumption was 82 gallons per capita or a total of 4,939,617 gallons. This was the average; but there was a peak load of over 16,000,000 gal-

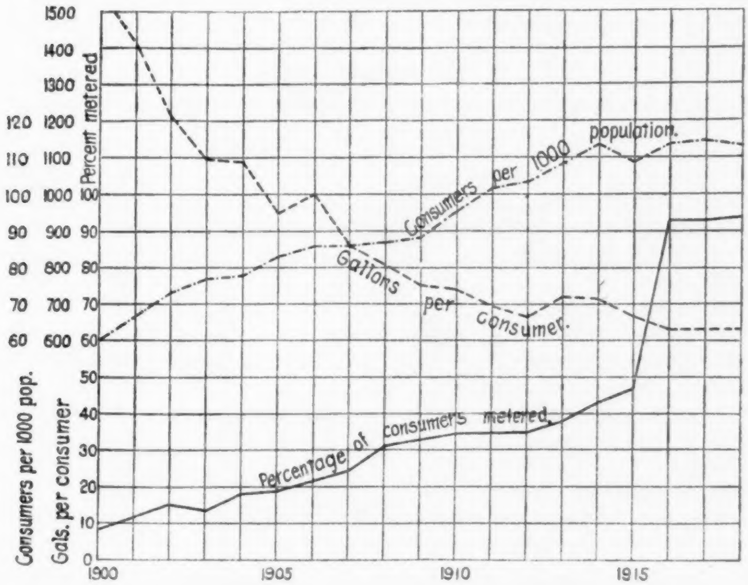


FIG. 1. PROGRESS IN METERING AND ITS EFFECT ON CONSUMPTION

lons per day during sprinkling hours on hot days. This produced such a draft on the works, which are of the direct pumping type, that had a serious fire occurred during such hours it would have been impossible to maintain adequate fire pressure. It became evident, therefore, that a meter should be installed on every flat rate service with a hose connection. The reasons for this step were explained carefully in detail in a circular mailed to the consumers before the meters were installed, which was done in 1916, and but two protests of importance were made against this metering, although 3700 meters were set in that year. As a result, in 1917, the hot-weather

peak load was less than 10,000,000 gallons, a reduction of over 6,000,000 gallons, and the average daily consumption was 4,813,765 gallons or 74 gallons per capita. The general consumption and meterage figures for the last eighteen years are shown in figure 1; the small number of consumers per thousand population was explained in the opening paragraph.

The effect of metering on the pumpage has been most interesting. In 1900, with 8 per cent of all the services metered, the pumpage was 1564 gallons per consumer, while in 1918, with 95 per cent of the services metered, the pumpage was 646 gallons per consumer. During the same period the per capita consumption was reduced

TABLE 1

Classification of the commercial class of consumers in Terre Haute according to the amount of water taken during 1918

QUANTITY TAKEN	NUMBER	PERCENTAGE OF ALL
Less than 750 gallons per month	553	7.8
750 gallons per month	898	12.6
1,500 gallons per month	933	13.1
2,250 gallons per month	1,060	14.9
3,000 gallons per month	1,061	14.9
3,750 gallons per month	702	9.9
4,500 gallons per month	477	6.8
5,250 gallons per month	320	4.5
6,000 gallons per month	226	3.2
6,750 to 9,750 gallons per month	492	6.9
10,500 to 19,500 gallons per month	239	3.4
20,250 gallons and over per month	141	2.0

from 90 to 74 gallons, and the number of consumers per thousand population was increased from 58 to 114, or 17 persons per live service in 1900 and 8.7 in 1918. The very important reduction of the peak load in 1916 and 1917 has already been referred to. This was an improvement in consumption conditions which directly assisted the pumping station records but did not materially affect the per capita consumption, since these peak loads only came during the sprinkling hours of hot days and did not have a great enough total influence to make any marked effect on the annual rates of consumption.

During 1918 there were four consumers who took a total of 1,500,000 gallons, one of them taking about 900,000 gallons per day. Over 99 per cent of the metered consumers are classed as commercial,

under the rules of the Public Service Commission of Indiana. This class does not include railroads, factories, public parks or street sprinkling carts. There were 7102 of these commercial consumers who took water in accordance with the figures given in table 1 and figure 2. The minimum rate allows the use of 3,000 gallons per month, so that 4,505 consumers, 63.3 per cent of all in this class, did not pay over $0.75 per month. The average amount of each bill in 1918 for commercial consumers, based on a rate of $0.25 per

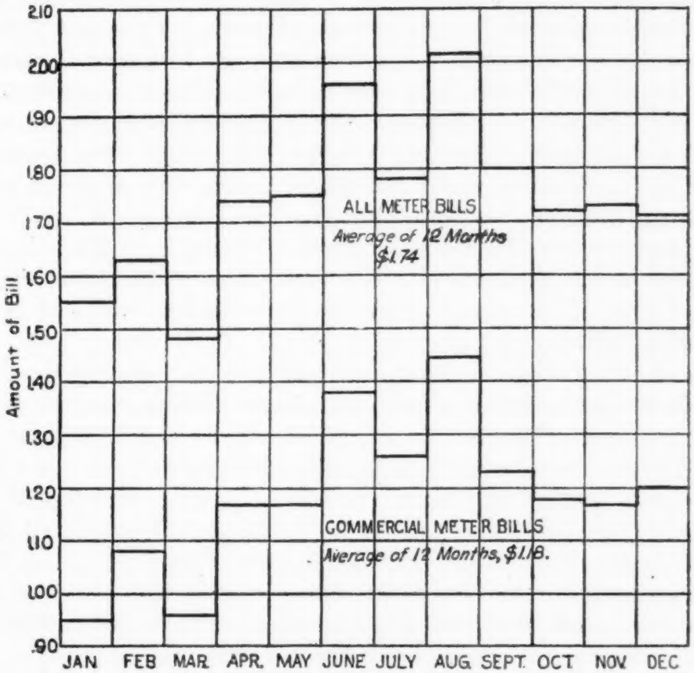


FIG. 2. AVERAGE MONTHLY METER BILL IN 1918

thousand for the first 20,000 gallons used in a month and $0.20 per thousand for the next 80,000 gallons used in the same month, was $1.25; the actual average was $1.18. Formerly the lowest rate was 5 cents per thousand for very large quantities, but this has been increased to $5\frac{3}{4}$ cents. For all metered consumers in every class the average monthly bill was $1.74. Only 2.3 per cent of the metered consumers of every class used over 20,000 gallons per month, on the average. At this writing 97 per cent of all consumers are metered.

The flat rate consumers are occupants of small houses with kitchen use only.

As is generally known, the subject of rates has been a most trying one in Terre Haute. In 1913 the annual flat rates were $5 for domestic use in a house with six rooms or less, plus $1 for each additional room. In addition there was a charge of $3 for a bath, $3 for a closet, $5 for 30 feet frontage of lawn requiring water for sprinkling plus 5 cents per foot for additional frontage, corner lots to be measured the longest way. In that year the minimum rate for $\frac{5}{8}$-inch meters was $12 per year and the rate for the first 20,000 gallons per month was $0.30 per thousand. In that year the company supplied 819 residences, apartment houses and boarding and rooming houses through meters. On the flat rate basis the average monthly payments would have been $1.86, while the average monthly payment by meter was $1.34, a reduction of $0.52, per month, or $6.24 or 23 per cent per year. During a period of about five years the average reduction in the revenue from this class of consumers through changing from a flat to a meter basis was about 25 per cent. The average daily use of water by these 819 consumers in 1913 was 150 gallons.

During the first three months of 1918 the minimum meter rate was $0.60 per month for small meters and during the last nine months it was $0.75. The company's records show that a group of 98 residence consumers, with bath rooms and hose connections, paid an average of $0.97 per month, or $0.65 or 40 per cent less than what the service would have cost on the flat rate basis. Had the minimum rate been $0.75 per month for the entire year, giving the consumers the right to take 3000 gallons per month, the average per month would have been $1.01, a reduction of 38 per cent from what would have been paid under the flat rate schedule.

The company furnishes the meters and installs them without charge. The consumer is liable for any injury to a meter due to any lack of ordinary care of the meter on his part. The company maintains the meter except when it is damaged by hot water. Every bill bears the announcement: "The company will test meters in the presence of consumers, free of charge." Very few consumers ask for such a test, but the offer to make it is a good business measure as showing the confidence of the company in its meters.

Where meters are set in cellars they are located below the floor level at the point where the service enters the cellar. The rules of

the company require the service pipes to be laid at a depth of not less than 4½ feet below the ground surface and to be laid under the foundations and at least 1 foot below the bottoms of cellars. A pit 20 by 26 inches, lined with brick or concrete, is constructed for the meter in the cellar. Either an iron cover or one made of 2-inch boards may be used. After the meter has been set it may be surrounded with sawdust or old newspapers to prevent freezing, if this is considered desirable. There are about 2000 meters installed in this way.

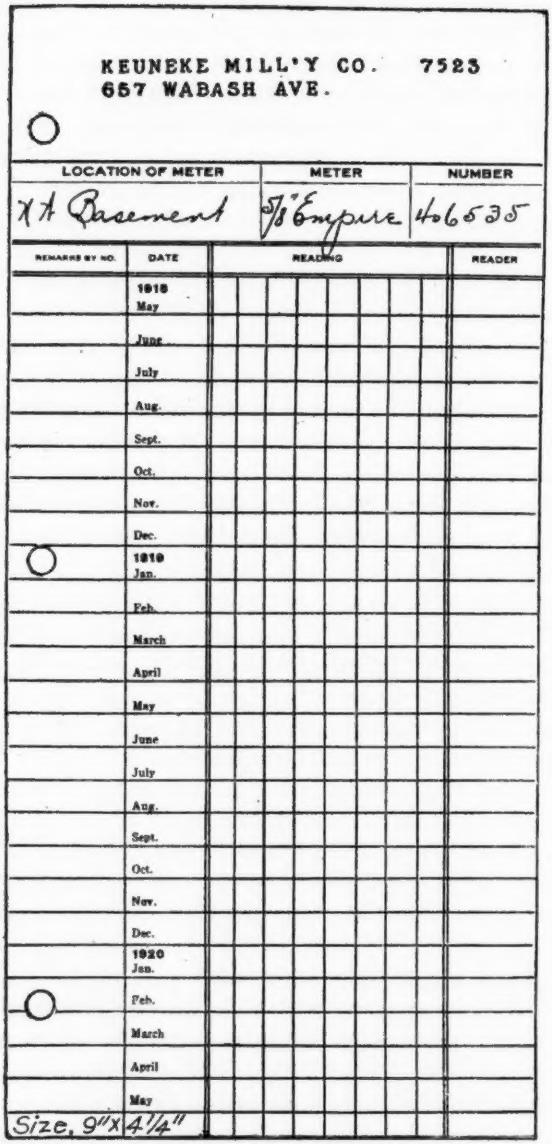
There are 317 meters installed in outdoor brick-lined pits 2 feet 8 inches in diameter at the bottom and 4½ feet deep. They have cast iron frames with covers giving an opening of 19 inches. No meter installed in such a pit in Terre Haute has ever been frozen.

In order to reduce the cost of such outdoor installations about 750 meters were placed in brick pits 3 feet 3 inches deep and 2 feet 8 inches in diameter at the bottom, with the same covers as the larger brick-lined pits. The meter was raised to within 3 feet 3 inches of the surface by risers, the pit containing these risers being backfilled with earth.

The next type of pit was made with a concrete tile 15 inches in diameter and 3½ feet long, provided with a Wabash cover 9 inches high having an 8-inch opening and an extra lid. This made the total depth of this pit 4 feet 3 inches. The meter was supported on a Ford yoke by risers holding it about 13 inches below the surface of the ground. Some of the later installations of this type were made with clay tile. Experience shows that better results would have been obtained in the sandy soil which is prevalent at Terre Haute with a tile 20 inches in diameter and about 5 feet long, and possibly vitrified clay tile would have been preferable to concrete in resisting cold. There are nearly 4000 meters set in pits of this type.

Recently the company has been using a pit made of two 2½-foot 20-inch vitrified sewer pipes, with a slot in the bottom of the lower one to fit over service pipes laid some years ago before the present rules concerning the depth of the services were in force. These pipes are provided with a Clark cover and coupling yolk. The cover is 6 inches high, making the total depth of the installation 5½ feet.

Including cost of providing service pipe from the main to the curb, the average 1918 cost of an installation of the type last described



KEUNEKE MILL'Y CO. 7523
657 WABASH AVE.

LOCATION OF METER	METER	NUMBER
X A Basement	5/8" Empire	406535

REMARKS BY NO.	DATE	READING	READER
	1918 May		
	June		
	July		
	Aug.		
	Sept.		
	Oct.		
	Nov.		
	Dec.		
	1919 Jan.		
	Feb.		
	March		
	April		
	May		
	June		
	July		
	Aug.		
	Sept.		
	Oct.		
	Nov.		
	Dec.		
	1920 Jan.		
	Feb.		
	March		
	April		
	May		

Size, 9"x4¼"

FIG. 3. FACE OF SHEET IN METER READER'S BOOK

MR. METER READER:

Please remember that you are the personal representative of the manager of this company; that our patrons will judge the Company and the manager by you, by your conduct, and by what you say; that to the people with whom you come in contact, you are the Company.

Politeness is cheap, but it pays big dividends.

If location of meter is not shown on card, make proper entry.

Endeavor to return reading of every meter for which you have a card.

Meter well covers should be carefully replaced and locked.

Make record under "Remarks" by number, when possible. The figure 13 opposite a reading will mean that you had noticed the high consumption and that you were SURE THAT THE READING WAS CORRECT.

DO NOT RETURN AN UNUSUAL READING WITHOUT AN EXPLANATION and when anything out of the ordinary is noticed, call attention to it by one, or more, of the numbers.

Refer all requests as to the quantity of water consumed, or to the amount of the bill, to the office—Telephone No. 215.

Report at the office about 5:45 P. M.—not later, telephone particulars if you cannot come.

Get acquainted with the numbers and use them.

When meters are in basements, let the people know that you are there to read the water meter. If the occupants are away, do not attempt to get in—if anything was missing you might be blamed.

Be sure to close all trap doors. Remember the Golden Rule.

1. **Meter not Registering.**
2. **Closet in basement leaking.**
3. **Closet on 1st floor leaking.**
4. **Closet on 2d floor leaking.**
5. **Closet was leaking—been repaired.**
6. **Kitchen faucet leaking.**
7. **Bath tub faucet leaking.**
8. **Basin faucet leaking.**
9. **Meter coupling leaking, inlet.**
10. **Meter coupling leaking, outlet.**
11. **Meter registering slowly, indicating a leak.**
12. **Did not find any leaks.**
13. **Consumption high; reading is correct.**
14. **Consumption low; reading is correct. Meter registers when faucet is open.**
15. **Covered, could not read.**
16. **Could not get in house.**
17. **Premises vacant.**
18. **Glass broken.**
19. **Counter broken.**
20. **Meter well needs attention.**

THE TERRE HAUTE WATER WORKS CO.

APRIL, 1918 10M

Size of sheet, 9"x4¼".

FIG. 4. REVERSE OF SHEET IN METER READER'S BOOK

The water consumption at No.______________________
street is larger than usual. It may be that an extra quantity of water is being used at this time, or possibly some of the fixtures may be leaking.

Whenever information of this kind comes to us, we like to pass it on to our valued customers, so that if there are leaks, they can have repairs made.

And please remember that we will be glad to send one of our men to inspect your water fixtures if you desire it. There is no charge for service of this kind.

Yours very truly,

THE TERRE HAUTE WATER WORKS CO.

Both Telephones No. 215.

____

Our meter reader called today and was unable to gain admission to your residence. To save your time, as well as ours, please read the meter, enter the figures on this card, date and mail.

THE TERRE HAUTE WATER WORKS CO.

Telephones 215 634 Cherry Street.

SIGNATURE

Reading of meter ______________________

______________________ No. ______________________

Date______________191___ Ledger No.______________________

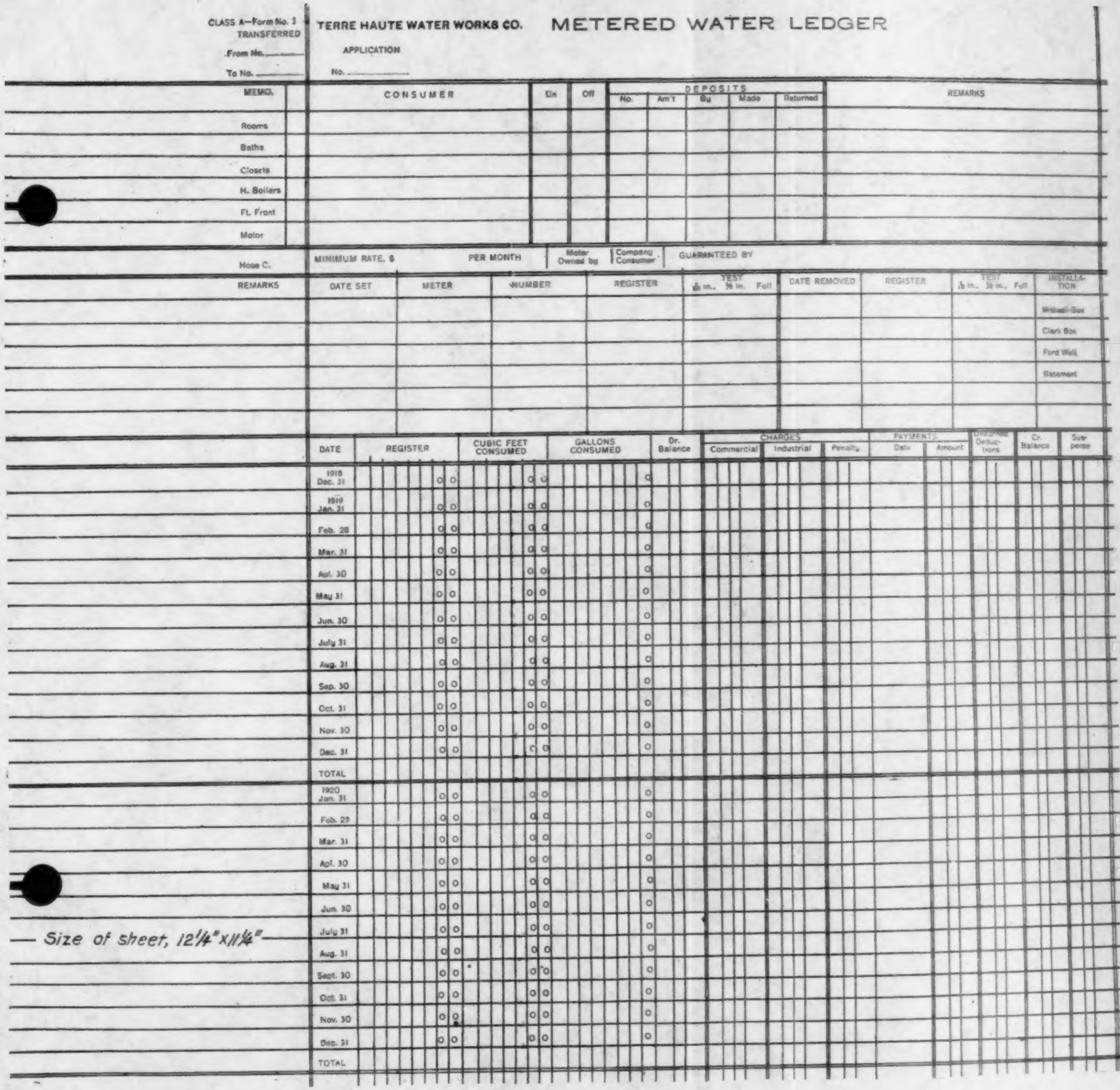
A second reading of the water meter at premises No. ______________________ shows that the former reading was correct. The reading as shown on the bill was ______________________: the second reading on ______________________ was ______________________.

Yours very truly,

THE TERRE HAUTE WATER WORKS CO.

____

Fig. 5. Three Postal Card Notices



CLASS A—Form No. 3
TRANSFERRED
From No. ....
To No. ....

TERRE HAUTE WATER WORKS CO.   METERED WATER LEDGER

APPLICATION
No. ....

MEMO.	CONSUMER	On	Off	DEPOSITS No.	Am't	By	Made	Returned	REMARKS
Rooms									
Baths									
Closets									
H. Boilers									
Ft. Front									
Motor									
Hose C.	MINIMUM RATE, $ PER MONTH	Meter Owned by	Company Consumer	GUARANTEED BY					

REMARKS	DATE SET	METER	NUMBER	REGISTER	TEST ⅛ in., ⅜ in., Full	DATE REMOVED	REGISTER	TEST ⅛ in., ⅜ in., Full	INSTALLATION
									Wabash Box
									Clark Box
									Ford Well
									Basement

DATE	REGISTER	CUBIC FEET CONSUMED	GALLONS CONSUMED	Dr. Balance	CHARGES Commercial	Industrial	Penalty	PAYMENTS Date	Amount	Unfunded Deductions	Cr. Balance	Suspense
1918 Dec. 31	00	00	0									
1919 Jan. 31	00	00	0									
Feb. 28	00	00	0									
Mar. 31	00	00	0									
Apl. 30	00	00	0									
May 31	00	00	0									
Jun. 30	00	00	0									
July 31	00	00	0									
Aug. 31	00	00	0									
Sep. 30	00	00	0									
Oct. 31	00	00	0									
Nov. 30	00	00	0									
Dec. 31	00	00	0									
TOTAL												
1920 Jan. 31	00	00	0									
Feb. 29	00	00	0									
Mar. 31	00	00	0									
Apl. 30	00	00	0									
May 31	00	00	0									
Jun. 30	00	00	0									
July 31	00	00	0									
Aug. 31	00	00	0									
Sept. 30	00	00	0									
Oct. 31	00	00	0									
Nov. 30	00	00	0									
Dec. 31	00	00	0									
TOTAL												

— Size of sheet, 12¼" x 11¼" —

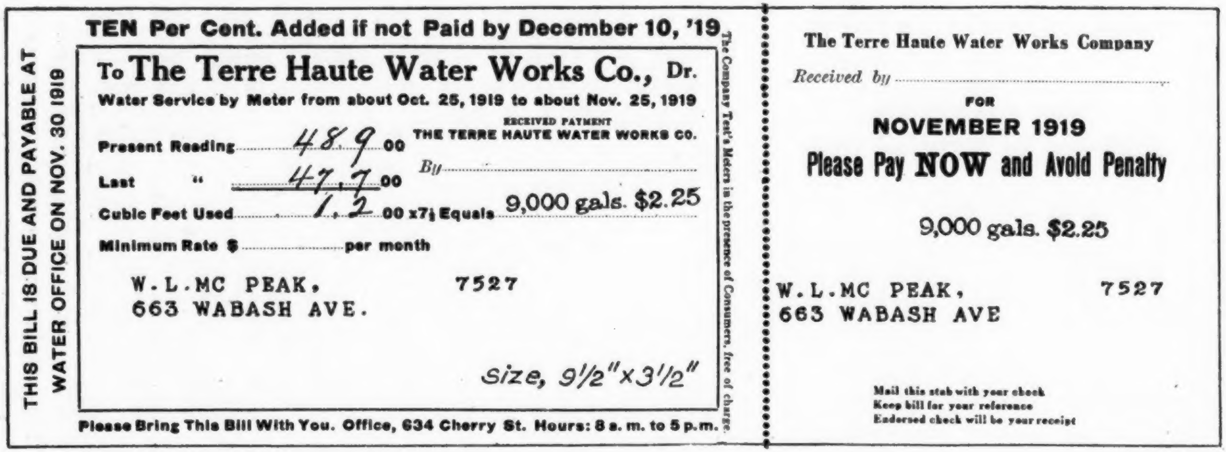
Fig. 6. Part of Sheet from a Loose-Leaf Metered Water Ledger

was \$16.47 for the service alone, made up of the following items: $\frac{5}{8}$-inch corporation cock, \$1.09; $\frac{5}{8}$-inch curb cock, \$1.66; $\frac{3}{4}$-inch brass tail piece, \$0.38; 17.1 feet $\frac{5}{8}$-inch extra strong lead service pipe, 3 pounds per foot, \$3.72; service box with $2\frac{1}{2}$-inch shaft, \$1.50; 10.9 hours labor at 35 cents, \$3.82; 2.2 hours labor at 40 cents, \$0.88; drayage, \$1.25; city permits, \$0.87; overhead on tools and equipment, \$1.30. In addition to this cost for the service there was an average cost of \$25.80 for the meter and its installation, made up of the following items: $\frac{5}{8}$-inch Empire meter, \$12.00; two tile, \$3.70; Clark cast iron cover, \$2.75; meter yoke, \$1.50; pipe and fittings, \$0.93; cement, \$0.37; 5 hours labor at 35 cents, \$1.75; 2 hours labor at 40 cents, \$0.80; drayage, \$2.00. This makes the total cost of the service and meter provided by the company, \$42.27, as an average during 1918.

The greatest recorded depth to which frost has penetrated the sandy soil of Terre Haute is 4 feet 7 inches. In a city not far distant where the soil is clay, frost does not penetrate to a depth of 3 feet. During the winter of 1917–1918 there were seventeen days when the Weather Bureau office at Terre Haute recorded temperatures of zero or below zero, with a minimum of 18° below. Out of the 7064 meters in service at that time, 616 or 8.7 per cent were frozen. None of the installations in the $4\frac{1}{2}$-foot brick-lined pits were frozen, 2.6 per cent of those in basements and cellars were frozen, 4.5 per cent of those in the 18-inch concrete tile pits, 11.2 per cent of those in 15-inch tile pits, and 16.2 per cent of those in brick-lined pits 3 feet 3 inches deep. Most of the cases of frozen meters in basements were due to open windows.

The first outdoor pits had non-locking covers, so that consumers could read the meters whenever they desired. Four complaints were received from persons who said they had been injured by stepping on loose lids, which turned under them. Two suits for a total of \$12,000 damages were brought on this account and settled at a cost of \$1000. This experience led the company to replace the old lids with locking lids and to use the latter type exclusively in subsequent installations. A few consumers object to them because they cannot read the meters whenever they wish, but the company offers to open the box upon request, which is very rarely made.

About the twentieth of each month a start is made in reading the meters, so that the bills may be ready for delivery on the last day of the month, when they are due. From ten to twelve readers



THIS BILL IS DUE AND PAYABLE AT
WATER OFFICE ON NOV. 30 1919

TEN Per Cent. Added if not Paid by December 10, '19

To The Terre Haute Water Works Co., Dr.

Water Service by Meter from about Oct. 25, 1919 to about Nov. 25, 1919

Present Reading 489 00
Last " 477 00
Cubic Feet Used 12 00 x7½ Equals 9,000 gals. $2.25
Minimum Rate $ .... per month

RECEIVED PAYMENT
THE TERRE HAUTE WATER WORKS CO.
By ....

W. L. MC PEAK, 7527
663 WABASH AVE.

size, 9½"x3½"

Please Bring This Bill With You. Office, 634 Cherry St. Hours: 8 a. m. to 5 p. m.

The Company Test's Meters in the presence of Consumers, free of charge.

The Terre Haute Water Works Company

Received by ....

FOR

NOVEMBER 1919

Please Pay NOW and Avoid Penalty

9,000 gals. $2.25

W. L. MC PEAK, 7527
663 WABASH AVE

Mail this stub with your check
Keep bill for your reference
Endorsed check will be your receipt

FIG. 7. FACE OF BILL AND ITS ATTACHED COUPON

Meter and Minimum Rates, as per order of The Public Service Commission of Indiana, April 1, 1919,

Apply to water registered by the meters in each month, being the period between the regular meter readings, about the 25th of each month, and are as follows:

For the first 20,000 gallons in one month.....25c per 1,000 gallons
For the next 80,000 gallons after the first 20,000 gallons in same month..........20c per 1,000 gallons
For the next 200,000 gallons after the first 100,000 gallons in same month..........14c per 1,000 gallons
For the next 700,000 gallons after the first 300,000 gallons in same month..........10c per 1,000 gallons
For the next 1,000,000 gallons after the first 1,000,000 gallons in same month .... 9c per 1,000 gallons
For the next 1,000,000 gallons after the first 2,000,000 gallons in same month .... 8c per 1,000 gallons
For all in excess of, or in addition to, the first 3,000,000 gallons in same month..0575 per 1,000 gallons

MINIMUM CHARGE OR RATE FOR METERED SERVICE

Every metered water supply service shall have a monthly minimum charge or rate on every meter installed, varying with and based upon the size of meter required and installed, in accordance with the rules of the Company, as follows:

MONTHLY MINIMUM RATE

Size of Meter	Without Fire Protection	With Fire Protection
⅝"	$ .75 for 3,000 gallons or less	
¾"	1.50	
1 "	3.00	$ 4.50
2 "	6.00	9.00
3 "	10.00	15.00
4 "	15.00	22.50
6 "	75.00	112.50
8 "	100.00	150.00

A delayed payment charge of ten per cent. will be added to all bills not paid within ten days after due.

Where two or more meters are used on the same premises by the same Consumer, the minimum charges or rates may be combined and the consumption through the two or more meters added together and figured as if the entire quantity had passed through one meter; this also applies to municipalities, street sprinkling contractors and railroad companies.

MINIMUM PERIOD.

4. On all metered water supply services, each and every month shall be a complete period in itself and no excess consumption of water during one month shall be charged against the minimum charge, or rate, or be added to the consumption of any other month, or months.

TEMPORARY METER SERVICE RATES.

6. Where water is desired on the meter basis for only a portion of the year, such as use for building purposes, street paving, or for sprinkling in Summer months, the amount paid each time the meter is used (for period less than one year) shall be at least twelve (12) times the monthly minimum rate; for street paving contractors, this means each time the location of the meter is changed.

If a consumer has water on for sprinkling and should vacate the premises, or there should be a change in occupants of the premises during the Summer, the charge will be equitably apportioned.

Perforated

Fig. 8. Notice on Back of Bill

are employed, mainly men used regularly by the company in various capacities. On Saturdays three or four high school boys are employed on meter reading, for which service they are paid 35 cents an hour. The readings are entered on heavy linen sheets, figures 3 and 4, about 200 of which can be placed in a loose-leaf binder. The name, street number and ledger number are printed on these sheets by an addressograph machine, and experience shows that the readings are expedited by giving the general location of the meter on the sheet.

There are 37 meter-reading routes, two of which are covered by men who ride bicycles. At the office there are portable blackboards 31 by 42 inches in size, with painted headings and lines numbered to correspond with the numbers of the meter books. The headings are: "Reader, Time out, Time in." The reader writes his name and time out opposite the number of the book he takes, which must be the one next above the last one recorded, for the readers are not allowed to select particular books or routes. The average number of readings per hour ranges from 30 in April to 22 in June. The best individual record was an average of 49 per hour in April and the lowest in that month was 22.

The average cost of reading meters for the year ending June 30, 1919, was $184.60 per month. As there were 7462 meters this was about 2½ cents per meter. The expense is materially increased by the necessity of going back over the routes in order to read meters in basements which could not be entered during the first trip, and by extra readings where it seems probable that an error has been made. Where the house is locked but there are indications that somebody is home evenings, a stamped postal card, figure 5, is sent with a request that the meter be read and the reading reported on the card.

Loose-leaf ledgers, figure 6, are used, arranged in order on the different streets, beginning with the lowest numbered streets, then the diagonal streets, and finally those at right angles with the numbered streets. The meter routes follow the arrangement of the accounts in the ledger as closely as possible. At the front of each reading book is the monthly record of the clerks who enter the readings. Each clerk is provided with a table showing for each 100 cubic feet the equivalent number of gallons and the charge for that amount at schedule rates. This table runs up to 32,000 cubic feet.

After the readings and charges are entered in the ledger, a second clerk copies the readings and cubic feet on the bills, figures 7 and 8, previously addressed on the addressograph. A third clerk stamps the gallons and amount due. Rubber stamps are provided for each 100 cubic feet and are so marked on top; on the face is shown the equivalent number of gallons and the amount due, figure 9. These stamps are arranged in a special case to facilitate their use. Later the bills are compared with the ledger to detect errors and omissions.

Except for about 200 accounts, all bills are delivered by messenger directly to the consumer, who is expected to pay the messenger. About 40 per cent of them do pay in this way. This delivery is made on the last day of the month by some of the regular employees of the company and by about 15 to 18 extra helpers, mostly women and girls, who are paid $3 for about eight hours work.

750 gals. Minimum 75¢	5,250 gals. $1.31
2,250 gals. Minimum 75¢	7,500 gals. $1.87
3,000 gals. Minimum 75¢	25,500 gals. $6.10
3,750 gals. 94¢	72,750 gals. $15.55

Fig. 9. Some of the Rubber Stamps Used on Bills

They must furnish references and are expected to read the company's instructions for the work, which are reprinted here, each morning before starting out, no matter how many times they have acted as messengers.

Instructions in Regard to Delivering Water Bills

Report at office not later than 5:00 p.m.

Be sure you deliver the bills to the premises indicated on the bills. Ring the door bell, or knock and give every one an opportunity to pay the bill. We have complaints every month from some of our customers that our men do not give them a chance to pay their bills. Always endeavor to get the bill in the hands of the occupant of the premises.

Say to the consumer that he can pay the bill now, if he so desires and it will save him a trip to the office; that the bill should be paid before the 10th

of the month, as a 10 per cent penalty is added to the bill after the 10th of the month. Emphasize the fact that you are authorised to give a receipt and save them a trip to the office.

Collectors will be held responsible for the amount of money shown on the coupons and part payment should not be accepted on any bill; collect the entire amount, or none at all.

If the bill is paid, receipt same with your name and date and bring the stub, or coupon, to the office. *Take good care of the coupons.*

All bills which are receipted and show a credit balance on same are for consumers who have made an advance payment. Deliver such receipts to the consumer, but do not collect any money on same.

In making change, count your money very carefully; do not get confused while counting by carrying on conversation; when currency is handed to you, put it between your fingers until you have made the change, so that if there should be any question on the part of the customer as to whether the bill was a $1.00 or $5.00 bill, you would be in position to determine the matter.

Do not discuss amount of bills of other people, nor tell one consumer the amount of another consumer's bill. Do not show one consumer's bill to another consumer, nor discuss in any way the amounts charged. If the consumers want information, refer them to the office. Consumers will frequently state that the collector gave them information.

If no one is at home, place the bill in the mail box, or under the door.

If there should be any objection to the bill, suggest to the consumer that he call the office, telephone 215.

If premises are vacant, mark bill "*Vacant*" and bring to the office.

Be courteous to all. Smile and keep on smiling. Courtesy is cheap but it pays big dividends.

When you return to the office, see that all coupons are signed by you and dated. Give your coupons to one of the office girls who will list them for you.

Get a box from one of the office force to put your money in.

Take out your change and give it to one of the office girls, who will check it as returned.

Arrange your currency so that the larger bills will be on the bottom, all face up, and see that all bills are smoothed out and neatly arranged. Stack your silver in piles of each denomination and place them in a box with currency. Check the amount of each on a slip of paper and see if total agrees with that shown as the amount of your coupons.

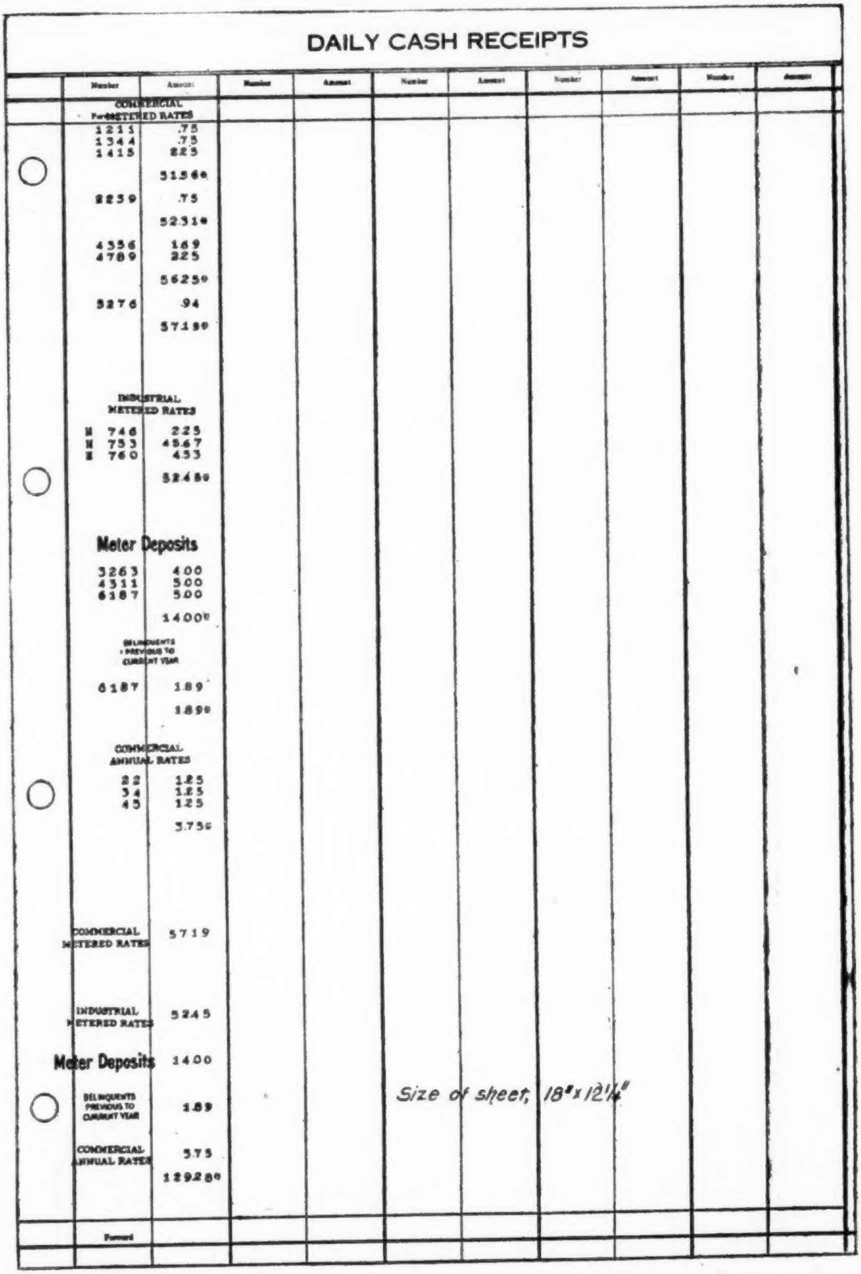
Sign and date the coupon slip. Count coupons and enter number on slip. Place coupons in box with money and turn in to Secretary if amounts of cash items agree with total of coupon slip.

The routes are already laid out for them, so there need be little delay in beginning work. Three dollars in change, a large pocket book for currency and detached coupons, and two street car tickets are furnished to each messenger. They are held responsible for the money they collect and there are rarely shortages of more than a few cents. As soon as they reach the office the coupons are

Name	Time Rec'd	Change	Coupons	Amount	
Mrs Heaton	4:20	3.00	75	$76.69	Finished
Miss Smith	4 P.M.	3.00	97	92.04	Fin.
Miss Wilhelm	5.15	3.00	80	103.76	Fin.
E. Kilby	4:50	3.00	82	85.54	Not Fin.
Mrs. Newton	1:30	—	106	139.05	Fin.
W. Cooke	2:50	—	64	74.84	Fin.
Mrs. Kautz	3:20	—	56	64.08	Fin.
Earl Johnson	5.15	3.00	57	56.58	Fin.
C. Johnson	5 P.M.	3.00	72	74.37	Fin.
C. A. Griffin	5 P.M.	3.00	52	46.25	Not Fin.
Miss Harper	1.30	—	96	160.07	Fin.
Mrs. Connelly	4:20	3.00	73	69.73	Fin.
Paul Smith	5:15	3.00	68	78.17	Fin.
Francis Bennett	1:40	—	22	45.21	Fin.
W. Biefield	5:20	3.00	69	72.59	Fin.
H. W. Cupps	5:20	3.00	120	126.71	Fin.
R. Bills	5 P.M.	3.00	82	80.20	Fin.
M. Mandeville	3:45	—	113	176.57	Fin.
H W DeLong	5:20	3.00	125	154.36	Fin.
Mrs. Bucherer	4 P.M.	3.00	42	56.21	Fin.
Mrs. Jackson	5:10	3.00	66	61.56	Fin.
Helen Burr	5 P.M.	3.00	84	79.56	Fin.
H. Kadel	3:50	—	114	293.98	Fin.
R. Crawford	5:15	3.00	80	77.36	Not fin.
Edna Bennett	5:15	3.00	38	34.82	Not Fin.
	P.M.		2nd Route		
Mrs. Newton	5:20	3.00	14	18.74	Fin.
Miss Harper	5:10	3.00	24	28.31	Not Fin.
Francis Bennett	5 P.M.	3.00	23	45.21	Not Fin.
W. Cooke	5:20	3.00	12	14.92	Not Fin.
Mrs. Kautz	5 P.M.	3.00	3	4.12	Not Fin.
Taylor	5:15	3.00	28	26.89	Not Fin.
Total			2037	$2518.49	

Size of sheet, 13¼" × 8¼".

FIG. 10. COLLECTION RECORD, JULY 31, 1919



DAILY CASH RECEIPTS

	Number	Amount	Number	Amount	Number	Amount	Number	Amount	Number	Amount
	COMMERCIAL METERED RATES									
	1211	.75								
	1344	.75								
	1415	225								
		5156								
	2259	.75								
		5231								
	4356	169								
	4789	225								
		5625								
	5276	.94								
		5719								
	INDUSTRIAL METERED RATES									
	M 746	225								
	M 753	4567								
	M 760	453								
		5245								
	Meter Deposits									
	3263	400								
	4311	500								
	6187	500								
		1400								
	DELINQUENTS PREVIOUS TO CURRENT YEAR									
	6187	189								
		189								
	COMMERCIAL ANNUAL RATES									
	22	125								
	34	125								
	45	125								
		375								
	COMMERCIAL METERED RATES	5719								
	INDUSTRIAL METERED RATES	5245								
	Meter Deposits	1400								
	DELINQUENTS PREVIOUS TO CURRENT YEAR	189								
	COMMERCIAL ANNUAL RATES	375								
		12928								
	Forward									

Size of sheet, 18" x 12¼"

FIG. 11. METHOD OF MAKING ENTRIES ON DAILY CASH RECEIPT BOOK WITH RUBBER STAMPS AND ADDING MACHINE

delivered to a clerk who lists them on an adding machine while the money is counted. The company has never had a dishonest messenger and the service has proved a great convenience to consumers in making it unnecessary for them to visit the office to make payments.

The actual collections made on July 31, 1919, are shown in figure 10. Figure 11 is a much reduced copy of a sheet from the Daily Cash Receipt Book, which shows how the records of the collections are kept. The name of the consumer is not entered, but instead the "number" of his ledger account, and the "amount" received. The engraving is so reduced in size that the five pairs of column

FUTURE PAYMENT FUND

Some of our valued customers have expressed the wish that they could pay their meter bills in advance and avoid the bother of monthly payments, the writing of small checks, etc.

Hereafter, the Company will accept sums from $3.00 to $10.00 for Future Payment Fund and will deduct current bills as they accrue and send a statement each month showing the credit balance.

This plan may be a convenience to the busy man and to those who are out of the city a good deal of the time.

The Future Payment Fund is to be entirely separate and distinct from deposits made to secure payment of bills

The Terre Haute Water Works Co.

Size, 5″×3″

FIG. 12. NOTICE OF FUTURE PAYMENT FUND

headings of "number" and "amount" are indistinct. Entries are made with rubber stamps and an adding machine. At the end of a day's collections, which may cover several pages, they are recapitulated for posting in the General Cash Book. This General Cash Book is arranged so that the totals for each day are in one line, the amounts being entered under the proper headings. At the end of the month, the totals for the entire month are posted into the Ledger. This system has been found to save a great deal of time. The company also uses loose sheets uniform with the daily cash receipts, which are headed Accounts Receivable. After the charges have been made in the Consumers' Ledger, the amounts are listed

on the sheets, with the numbers, by the adding machine in the same way that the receipts are entered on the Daily Cash Receipts book. At the end of the month, the daily cash receipts plus the delinquents and minus the accounts charged previous to the current month should equal the accounts receivable.

Dear Customer:

Thank you for the business you have given us which is appreciated. We want to continue to supply you with water so that whenever you, or any member of your family, turn the faucet, the pure filtered water will flow.

And we would like very much to have you take advantage of our lowest rates by paying at the first of the month. After the tenth of the month, the cost is ten per cent greater, whether a notice was received or not. The order of the Public Service Commission simply states that "a delayed payment charge of ten per cent will be added to all bills not paid within ten days after due."

Please let us have a check or cash within the next day or two for the amount past due, as shown on the reverse side.

Yours for Good Water Service.

THE TERRE HAUTE WATER WORKS CO.

OVER

Dear Customer:

Pardon this reminder, but our books do not show payment of water bill due on the last day of last month. If you have a receipt for this charge, please call us at once by either phone, No. 215; otherwise, kindly let us have check or cash within the next day or two for the amount stated on the other side.

Water meters are read between the 20th and 25th of each month and the *BILLS ARE DUE ON THE LAST DAY OF THE MONTH*. After the the tenth, the cost is 10% greater.

We are planning, spending and working to make your water service as near perfection as possible and ask your co-operation.

Yours For Good Water Service,

THE TERRE HAUTE WATER WORKS CO.

OVER

Size, 6 1/2" x 3 1/2"

FIG. 13. TWO WARNINGS OF ADDITIONAL PAYMENT REQUIRED AFTER TENTH DAY OF THE MONTH

The average number of coupons brought in on one collection day was 87, the total being 2270. Of the 35 routes, about 25 are covered by the messengers on the last day of the month and the remainder on the following day. The average cost of delivering bills by hand for the six months ending June 30, 1919, was $126.91 per

month. The average cost per bill was 1.76 cents, including the cost of collecting the 40 per cent of the bills that are paid on delivery. There is a delayed payment charge of 10 per cent when bills are not paid within ten days after they become due. From 93 to 94 per cent of the consumers pay by the tenth of the month. The additional 10 per cent is always collected.

The company has adopted the principle of accepting small deposits from customers to enable them to avoid the inconvenience of visiting the office to pay small bills. Figure 12 is the notice sent out from

THE TERRE HAUTE WATER WORKS CO.

OFFICE 834 CHERRY STREET TELEPHONE 215

TERRE HAUTE, IND.

____

____

We wish to acknowledge receipt of your check for $________ enclosed in envelope bearing Terre Haute post office stamp of______________

Under the order of the Public Service Commission of April 12, 1918, 10% is added to bills that are not paid within ten days after the same are due. Therefore, we are placing the amount of check to your credit which leaves a balance due of $________; this will be added to the next bill.

Yours very truly,

THE TERRE HAUTE WATER WORKS CO.

P. S. At the suggestion of one of our customers, we have arranged to accept advance payments of $3.00, $5.00, or $10.00. This plan is attractive to those who are frequently out of the City and to those who do not wish to be bothered with small bills. Statements are furnished monthly showing credit balance.

T. H. W. W. CO.

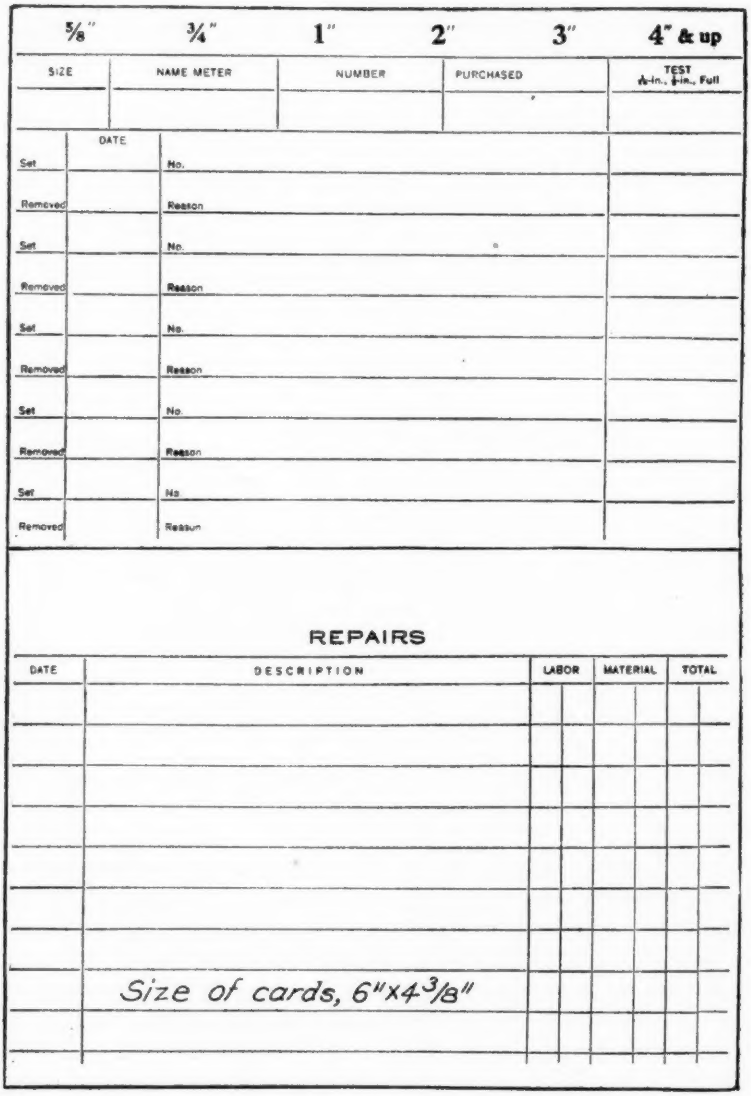
Size, 8½" x 6¼"

FIG. 14. RECEIPT ON ACCOUNT

time to time to call attention to this policy. Various warnings are given to consumers regarding the automatic increase of 10 per cent in their bills after the tenth of the month, in accordance with the regulations of the Indiana Public Service Commission. Figure 13 gives two of these slips. When a consumer remits the original amount after the tenth of the month, he is sent the "receipt on account" reproduced in figure 14.

The records of individual meters are kept on cards, figure 15. The top of the card is cut off leaving only the stub indicating the size of the meter whose history is recorded on that card. Three sets of

loose-leaf meter record-books are kept, as shown in figure 16, which have proved very convenient, complete, and easily posted.



5/8″ 3/4″ 1″ 2″ 3″ 4″ & up

SIZE	NAME METER	NUMBER	PURCHASED	TEST 1/16-in., 1/8-in., Full

	DATE		
Set		No.	
Removed		Reason	
Set		No.	
Removed		Reason	
Set		No.	
Removed		Reason	
Set		No.	
Removed		Reason	
Set		No.	
Removed		Reason	

REPAIRS

DATE	DESCRIPTION	LABOR	MATERIAL	TOTAL
	Size of cards, 6″x4-3/8″			

FIG. 15. FRONT AND REVERSE OF METER RECORD CARDS

Form No. 9 B

RECORD OF METERS SET—THE TERRE HAUTE

	Date		Consumer	Location	Name and Size of Meter	Number of Meter	Register	Test ¼", ½" Full
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								

Form No. 9 C

RECORD OF METERS REMOVED—THE TERRE HA

	Date		Consumer	Location	Name and Size of Meter	Number of Meter	Register	Test Before Opening
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								

Form No. 9

METERS REPAIRED—THE TERRE HAUTE W

	Date	Name and Size of Meter	Number	Tests: Before Opening ¼", 1" Full	Tests: After Repairing ¼", 1" Full	Cost of Repairs: Labor	Cost of Repairs: Material	Total	Received for Repairs	Ledger No.	
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											

Fig. 16. Parts of Loose-Leaf Sheets Used in Keepin

HE TERRE HAUTE WATER WORKS CO.

of	Register	Test 1/16", 1/8" Full	First Install. Cost	Metered Heretofore	Ledger No.	Why Set—Remarks

—THE TERRE HAUTE WATER WORKS CO.

of r	Register	Test Before Opening	Meter Changed	Meter Discontinued	Ledger No.	Why Removed—Remarks

ERRE HAUTE WATER WORKS CO.

red rs	Ledger No.	Description of Repairs Made	Repaired By
		Size of each sheet, 17¼" x 14"	

Used in Keeping Meter Records

FINAL REPORT OF THE COMMITTEE ON SANITARY DRINKING FOUNTAINS OF THE IOWA SECTION OF THE AMERICAN WATER WORKS ASSOCIATION[1]

Introduction. The war against the common drinking cup has been won. This victory, however, must not be allowed to blind us to the dangers lurking in the usual substitute for the common drinking cup, the so-called sanitary drinking fountain. With amazing rapidity these bubbling fountains have invaded our public streets, our schools, our libraries, our playgrounds and our hotels. Approved by public health authorities of high standing and by journals of wide circulation, the bubbling drinking fountain has met little or no opposition until very recently. Within the past few years, however, several elaborate series of laboratory experiments have been made upon most of the prevailing types of bubbling fountains. These experiments, supplemented by its own observations, have led your committee to the following conclusions.

Conclusions. 1. All types of drinking fountains with vertical jets are to be condemned.

2. Most types of drinking fountains with slanting jets are to be condemned.

3. To be sanitary, drinking fountains should conform to the following specifications:

a. The jets shall be slanting.

b. The orifices of the jets shall be protected in such a manner that they cannot be touched by fingers or lips, or be contaminated by droppings from the mouth, or by splashings from basins beneath the orifices.

c. The guards of the orifices shall be so made that infectious material from the mouth cannot be deposited upon them.

d. All fountains shall be so designed that their proper use is self-evident.

[1] Read and adopted at the annual meeting of the Iowa Section at Mason City, October 23, 1919. Discussion of this report is requested and should be sent to the Editor.

These conclusions are based, first, upon observations of public fountains while in use and, second, upon bacteriological investigations of public fountains under laboratory conditions.

Observations of public drinking fountains while in use. The following quotation from the Detroit *Journal* is taken from a clipping sent out by one of the manufacturers of drinking fountains. It purports to be part of a warning issued by the Michigan State Board of Health.

> Statistics gathered by a federal inspector in a railway station show what may happen. He found 47 persons used the fountain in an hour. Of these, 11 were men, 22 women and 14 children. But in almost every instance, he reports, the lips were placed completely around the metal ball from which the water spurted and one small boy acted as though he were trying to swallow the whole machinery. Of the 47 people, four were colored, three looked as though they were unmistakedly victims of tuberculosis, and three had eruptions on their face.

In its progress report read in 1917 at Council Bluffs at the third annual meeting, your committee reported the following results of its observation of the use of two fountains without mouth guards. One fountain was of the continuous-flow type with a bubble $\frac{5}{8}$ inch in height. It was located in a public library. During the period of observation, 59 persons drank from this fountain, 22 of whom were children and 37 adults. Of the 22 children, 15 placed their lips upon the metal top of the bubbler, while only 7 did not. Of the 37 adults, 28 placed their lips upon the metal top, while only 9 did not. One adult had an eruption upon the face and one was apparently in bad general health.

The second fountain was of the intermittent-flow type with a bubble $\frac{3}{4}$-inch in height. It was located at a street corner. During the period of observation, 43 persons drank. One was a small child which had to be held up in order to drink. This child placed its lips upon the metal top of the bubbler. Of the remaining 42 persons, 18 were children and 24 adults. Ten of the 18 children placed their lips upon the metal top, while 8 did not. One of these children was apparently in bad general health. Nine of the 24 adults placed their lips upon the metal top while 15 did not.

A thorough investigation of methods used by drinkers has been made by Dr. J. J. Kinyoun and Dr. Louis V. Dieter, under the direction of the Drinking Fountain Committee of the Health Department of the Commissioners of the District of Columbia. In

observations of the methods used by 1500 to 2000 drinkers from practically all types of fountains, these observers were greatly impressed by the large proportion of persons who cannot drink from a bubbling fountain unless they grasp the nozzle with the lips. Certain individuals with large redundant lips are able to reach down beyond the guard, which is placed on some of the bubblers, and grasp the nozzle with the lips in spite of it. Where they are not successful in the attempt to grasp the nozzle with their lips, they do succeed in bringing their lips near enough to the nozzle to allow drippings from the mouth to fall upon it. Moreover, the guards which are being placed on the new type of slanting jet fountain usually consist of projections so placed that the upward flow of the water, as it describes its arc, passes very close to the edge of the guard. Actual observations show that at least 40 per cent of the drinkers place their mouths directly on the guard, and by thrusting their heads in the direction of the nozzle not only allow drippings from the mouth to flow over it, but also seriously contaminate the guard itself with mouth organisms.

Furthermore, these observers call attention to the frequent contamination of the nozzles of fountains by the hands and fingers. In observations made in schools and playgrounds, the conclusion was reached that nearly 50 per cent of the children, particularly boys, play with the fountains in an attempt to squirt one another, or otherwise amuse themselves. Moreover, the child is not the only offender in the contamination of the nozzle with the fingers, for adults have been observed to wipe the nozzle carefully with their dirty hands and then grasp the nozzle with their lips while drinking.

The following quotation from an article by Dr. Dieter, soon to be published, indicates the dangers resulting from finger contamination.

> That the danger from finger contamination was not hypothetical but a proven fact, was shown by a series of tests made in the schools during the recess period, when we isolated, besides other organisms, in six instances the Bacillus coli, an organism whose normal habitat is the intestinal canal. The significance of the finding of this organism on the nozzles, that had been free from it immediately preceding the test, lies in the possibility of communicating typhoid in this manner from carriers. That we did find this organism was as might have been expected, considering the fact that some of the children make a dash directly from the toilets to the drinking fountain and commonly finger the nozzle in play even before drinking. Furthermore, how many children's fingers are free from germ-laden mucus from the nose and from the mouth, even more dangerous as a general rule than other impurities?

In connection with the tests made under practical conditions, following the use of these fountains by drinkers, we have isolated mouth bacteria in all instances, principally streptococci, pneumococci, an organism morphologically identical to the influenza bacillus and in three instance an organism having all the microscopic characteristics of the diphtheria bacillus. There is no doubt that, from the physical appearance of some of the drinkers we have observed, we could have isolated the bacillus of tuberculosis, or the organism responsible for syphilis, had it been possible to do so with our present methods for the cultivation of these organisms. Swab cultures made from the guards that were brought in contact with the lips of persons during the process of drinking, on some of the side-stream types, showed the presence of mouth organisms in nearly all instances.

Results of bacteriological experiments on public drinking fountains under laboratory conditions. Nozzles of drinking fountains now on the market may be classified as follows:

A. Vertical jet nozzles.

1. Nozzles consisting of bowls which do not drain out, with the result that the incoming jet passes through the water in the bowl.

2. Nozzles consisting of bowls which fill with water when in use, as in class 1, but which drain out more or less quickly when used intermittently.

3. Nozzles with perforations, or slits, or one single outlet, with free overfall for waste water. The incoming jets do not pass through cups or bowls of water.

B. Slanting jet nozzles.

1. Nozzles with a series of holes so arranged around the periphery of a horizontal circle that the separate jets from the holes impinge and produce a bubble in the center.

2. Nozzles throwing a single slanting jet at an angle with the vertical.

Under each of these classes are many different types, any of which may be arranged for either intermittent or continuous flow. Fortunately the laboratory tests now on record include practically all of the types of the various classes.

The earliest published laboratory tests on bubbling fountains are those of Jane L. Berry of the Bureau of Laboratories of New York City. She experimented with but a single type of fountain, having a vertical jet and a cup which could not be drained when in use, through which the incoming jet came. It is interesting to note that the manufacturer had invented an arrangement by which the cup could be drained when in use, but he did not recommend the

arrangement, because the dry cup would accumulate dust which might not readily wash out and secondly, because the full cup is a necessary preliminary before the bubble effect can be obtained, and is the best safeguard against too strong an upward current when the water is first turned on. These ideas probably account for the popularity of this type of fountain with both manufacturers and drinkers.

In testing the fountain a broth culture of coli communis was rubbed on the lip of the empty cup and then recovered in considerable numbers later in the bubble. Similar results were obtained when the coli communis culture was applied to the inside surface of the bottom of the empty cup.

The next experiments that are on record are those by Pettibone, Bogart and Clark of the Laboratory of Medical Bacteriology of the University of Wisconsin. The immediate occasion for starting these investigations at the University of Wisconsin was an epidemic of streptococcus tonsillitis which occurred in the fall of 1914 in one of the women's dormitories. In seeking to find the source of the spread of this epidemic, the drinking fountains were examined and found to be heavily contaminated with streptococci. Subsequent to this, the bubble fountains on the campus of the University of Wisconsin were investigated. On one occasion 43 out of 77 bubble fountains, or about 56 per cent, were found to be contaminated with streptococci. On a second occasion, 35 out of 50 fountains, or 70 per cent, were found to be contaminated with streptococci. As a result of their bacteriological tests, these experimenters formulated the following conclusions:

1. During an epidemic of streptococcus tonsilitis in a women's dormitory of the University of Wisconsin, streptococci were found in the bubble fountains in this building and in the water issuing from these fountains.

2. The city water supply was at the time, and has been, excellent in its sanitary character. It is obtained from the underlying Potsdam sandstone. No streptococci were found in a Berkefeld filter through which water had been flowing continuously for one week.

3. Presumably the bubble fountains were a factor in transmitting the disease.

4. A survey of all the fountains of the University showed the presence of streptococci in over 50 per cent of the total number. The streptococci varied in abundance from a few chains to an almost pure culture obtained by swabbings from the fountains of the women's dormitory.

5. In an experimental bubble fountain, B. prodigiosus when introduced either by means of a pipette or by the moistened lips, remained in the water from 2 to 135 minutes, depending partly on the height of the bubble.

6. Most of the organisms are flushed away, but some remain dancing in the column much as a ball dances on the garden fountain, even though the bubble is increased to the impractical height of 4 inches.

7. To avoid the difficulty always present in the vertical column, a simple fountain with a tube at an angle of fifty degrees from the vertical was constructed. B. prodigiosus was never found in the plates from this type of fountain even when samples were taken immediately after the introduction of the organisms.

8. We believe that this type of fountain should be generally adopted. Its simplicity, low cost of construction and freedom from lurking dangers should recommend it to all.

In 1917, H. A. Whittaker, Director, Division of Sanitation, Minnesota State Board of Health, published the results of an investigation of the drinking fountains of the University of Minnesota. He found that of 77 drinking fountains of 15 different types, 80 per cent were contaminated with streptococci. His results may be summarized as follows:

1. Eighty per cent of the fountains were infected with streptococci, which it is reasonable to assume came from the mouths of the consumers, as these organisms were not found in the water supplying these fountains.

2. Streptococci were actually present in the water discharged from 11 per cent of these fountains, and therefore could be transmitted to the mouth of the drinker even though the lips were not touched to the infected parts.

3. The principal defect in construction of the fountains was thought to be the vertical discharge of the water, which could be corrected by employing the principle of the slanting jet.

The conclusions of these experiments have been confirmed beyond all doubt by the remarkably thorough and exhaustive series of laboratory tests made by Dr. Kinyoun and Dr. Dieter. These experiments are soon to be published. Through the courtesy of Dr. Dieter, who has furnished the committee with an advance copy of his report, and through the kindness of I. M. Cashell, city manager of Goldsboro, N. C., who has supplied the committee with a copy of the official report of Major Kinyoun, the following summary has been made possible.

The experiments of Dr. Kinyoun and Dr. Dieter were started something over four years ago. Since then, ninety separate and distinct types have been tested in the laboratory, including about eight or ten so-called slanting jet types. These tests have shown conclusively that in all types of vertical jet drinking fountains bac-

teria, when introduced in the bubble, remain in the stream for several minutes. An attempt was made to determine the reason for the presence of the bacteria in the stream for so long a time when the cultures were poured directly on the bubble. It was concluded that while this was due to some extent to the organisms dancing up and down on the crest of the bubble, yet it was a much more important fact that there seem to be differences in the velocity of the water in the center and in the periphery of the stream, so that some of the bacteria are carried down toward the nozzle in an eddy. Particularly was this true in the case of mouth washings containing more or less viscous sputum, which when carried down to the nozzle, became attached to it in threads. Small particles of it together with bacteria would be washed up into the bubble for a considerable length of time.

Furthermore, these experiments prove that most of the slanting jet fountains do not come up to the standard specifications above suggested. The main trouble is faulty protection of the nozzle or the guard from finger or mouth contamination. It was clearly demonstrated, however, that bacteria, when introduced at the crest of the bubble of the slanting jet, would be immediately carried away. In this respect, slanting jet fountains are safe. When the nozzle and the guard are properly protected and constructed, such a fountain can be approved without hesitancy.

Recommendations. In view of the fact that all vertical jet drinking fountains are a menace to the public health comparable with the common drinking cup, and in view of the fact that most slanting jet fountains are not being designed in conformity with the specifications above suggested, it is recommended, if this report be approved by the Iowa Section, that an effort be made to have a committee appointed by the American Water Works Association to investigate the subject and report.

In case this cannot be done, it is recommended that copies of this report be printed and distributed as widely as seems wise among the leading popular and technical magazines, State Boards of Health, Public Health Societies, Medical Associations, etc.

Bibliography. A bibliography is appended to this report giving all the references to papers on sanitary drinking fountains with which your committee is acquainted.

Respectfully submitted,

J. H. Dunlap, *Chairman.*
Jack J. Hinman, Jr.
Dale L. Maffitt.

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WATER POLLUTION AT AUBURN, NEW YORK, DECIDED TO BE A VIOLATION OF THE STATE PENAL CODE[1]

By J. Walter Ackerman[2]

The City of Auburn, New York, derives its water supply from Owasco Lake, one of the so-called Finger Lakes of Central New York. It has a drainage area of approximately 200 square miles, and a surface area of 10 square miles. The tributary area has normally rural population, with a few villages on its upper reaches.

The Village of Moravia, of about 1500 inhabitants, has a high school with approximately 400 students. The Trustees of this high school caused a sewer to be constructed from the school building to Mill Creek, one of the tributaries of the main inlet stream of Owasco Lake. This building was about 4½ miles from the head of the lake. The water supply for the City of Auburn, which has a population of about 35,000, is taken at the other end of the lake, a distance of approximately 14 miles from the high school.

In October and November, 1907, twenty cases of typhoid fever developed on the watershed in and about Moravia. The major portion was in Moravia, and a number of them were students at the high school. The sewer was so situated that the feces from the village high school were discharged in the winter time, at low periods of water, upon the edge of the stream and collected there in large masses until the spring freshets carried them away.

The following spring an epidemic of typhoid fever occurred in Auburn, forty-five cases being reported, and there were twelve deaths. Allowing the usual percentage of fatality, this would indicate that there were probably upwards of a hundred cases.

This appeared so important that investigations were made, and eliminating all other sources of possible infection it was assumed that the Auburn epidemic came from the Moravia typhoid. While

[1] Discussion of this paper is desired and should be sent to the Editor.

[2] Chief Engineer and Superintendent, Board of Water Commissioners, Auburn, N. Y.

at this time this was a protected watershed, under the protection of rules and regulations promulgated by authority of the statute under the public health law, these rules were for local application. While the law gave the Auburn Water Board, which is charged with the responsibility for the supply, some police authority, it did not give the Board adequate jurisdiction to remove violations of this law. So the Board determined to institute an action against the Trustees of the Village High School of Moravia. Before this was done, however, a series of experiments was carried on by the author, at the suggestion of Prof. George C. Whipple, now of Harvard University, to determine what effect wind might have on surface velocity of the lake, to see whether it was possible that polluting material might be carried across from one end of the lake to the other within a period sufficient to transmit it within the lifetime of pathogenic bacteria. For a long series of experiments in which submerged floats were used, see article in the 1913 PROCEEDINGS of the American Water Works Association, page 291. It was proved that there was set up in the water a velocity from 1 to 3 per cent of that of the wind, and of the same direction as the wind. As wind velocities operate over wide areas, it was possible to take advantage of the anemometer records of the State Meteorological Station at Ithaca, New York, only 30 miles away. It was found that there were plenty of periods when the wind was blowing with a sufficient velocity, and continuous direction, to bring polluting material from Moravia to the place where Auburn secures its water in from three to four days. Other circumstances about the case were equally positive, and in order that definite and immediate action might be obtained, the case was brought by indictment, by The People against the Trustees of the Village High School. It was under Sections 1530 and 1532 of the Penal Code of the State of New York, as explained in the 1913 PROCEEDINGS of the Association.

The case was brought, and in the first instance was a mis-trial. In the second instance, the People were given the decision. The District Attorney was assisted by Prof. C.-E. A. Winslow, Prof. George C. Whipple, Dr. William P. Mason, Dr. F. M. Meder, Dr. Willis W. Waite, and Nicholas S. Hill, Jr. The decision under the Penal Code gave an immediate injunction against the Trustees of thd Village High School, restraining them from putting any more sewage into the stream. This is the advantage of trial by injunction, and for a crime. (See 1914 PROCEEDINGS of the American Water Works Association, page 688).

The judgment of the court in the first instance was as follows:

The judgment of this Court is, that the defendant, the Board of Education of the Union Free School, District No. 1, of the Town of Moravia, County of Cayuga, State of New York, be sentenced to pay the plaintiff, The People of the State of New York, a fine of $500. And in addition thereto, it is further

Ordered, Adjudged and Decreed, **that the nuisance described in the Third Count of the Indictment be abated. And the Sheriff of the County of Cayuga is hereby Ordered and Directed to abate the said nuisance, by so breaking or stopping up the outlet sewer leading from the school building, or stopping the use of the toilet closets in said school building, as to prevent the discharge of human excreta from said sewer or closets into said Mill Creek, or in the bed, or on the banks thereof, or into Owasco Inlet or Owasco Lake.**

The third count of the indictment is based upon the fourth subdivision of the definition of a public nuisance, in that it is charged that the conditions render a considerable number of persons insecure in life or the use of property.

The above verdict of guilty and order of the court, found in the Supreme Court, in March, 1914, was appealed from by the School Board. The Appellate Division of the Supreme Court, at Rochester, handed down a decision on May 26, 1916, sustaining the conviction of the defendants, which judgment was duly entered in Cayuga County Clerk's Office on May 31, 1916. Later, the judgment was satisfied by payment of the fine of $500. Nevertheless, the defendant continued its appeal to the Court of Appeals, where it was finally reached for argument on December 3, 1917. On December 18, 1917, the Court of Appeals unanimously affirmed the judgment of the Appellate Division, without opinion. The final judgment of the Supreme Court making the judgment of the Court of Appeals the judgment of the Supreme Court was granted and entered on December 29, 1917. That judgment finally terminated the case, and prevented further appeal.

This is a clean-cut case of pollution, carried through all the courts to a final unanimous judgment, and represents a method of attacking this problem which, if it has been used at all in other cases, has been rarely employed; for at the first trial of this case this was the first time, so far as the Auburn Board and its advisers were able to learn, that this method was used. It is simply reported here to get on record the general facts in the case, with its final favorable termination.

LEGAL RESPONSIBILITY FOR A PURE WATER SUPPLY[1]

By John Wilson[2]

The author understands he was asked to write a paper on this subject because he happened to be more or less closely associated with the typhoid epidemic at Mankato in 1908 and the legal proceeding resulting from it. The Mankato case in many ways was by no means an exceptional one; in fact it may be regarded as typical of the general municipal waterworks plant. There had never been any expert supervision of the quality of the water, there were few records and one mistake followed another just about as fast as election day came round and the victors took the spoils.

The history of Mankato's water supply as secured from a few of the old settlers is interesting. Some of the early officials were of the opinion that subterranean caverns existed and these were filled with water under great pressure. Now, if the crust overlying these caverns could be punctured the water would, of course, spout forth. In fact, it was only a matter of drilling deep enough before one such cavern would be encountered.

The first experiment was tried in 1874 and 1875 at a cost of $12,000. A well was drilled on the hilltop to a depth of 2204 feet. The elevation was selected in order to eliminate pumping and at the same time secure fire pressure in the mains. So firmly was the cavern idea fixed in their minds that they even found evidence of their existence while drilling. In their report on the well, they said: "At 1160 feet the drill fell a little and water rose 10 feet higher, at 1975 feet the drill again dropped and the water rose another 10 feet."

The drilling of this well did, however, reveal the fact that artesian water could be secured by drilling at the foot of the hill instead of at the top. But here the cavern idea again came up; these caverns

[1] Read before the Minnesota Section, May 3, 1919. Discussion of this paper is requested and should be sent to the Editor.

[2] Consulting civil and sanitary engineer, 300 First National Bank Building, Duluth, Minn.

would in time become empty, and the city would be obliged to look elsewhere for water. For this reason it was decided to locate the pumping station on the river bank. Just how it happened that the location selected was at the outlet of the main sewer the author was never able to ascertain, except that ground could possibly be secured there at small cost.

Previous to 1908 four wells had been drilled. These wells developed a pressure of from 10 to 12 pounds per square inch at the ground surface, and the discharge flowed by gravity to the pump. The pump was located in the basement, several feet below the ground surface.

The character of the water was such that the well casing did not last very long. It was much less trouble to fix up by-passes and waste than to repair wells. The main sewer passed within a few feet of the well and just in front of the pumping station. Accordingly a connection was made with the sewer and suction main, so that as soon as the pump was stopped the wells would flow into the sewer.

It was later decided to discharge the ashes into the river by flushing and another pipe was laid connecting the river and pumping station. This pipe being at a lower grade than that between the suction main and sewer, the waste from the wells flowed directly to the river. The Minnesota River at times reaches a very high stage and has on several occasions flooded the basements in the business section of the city.

In order to safeguard against backing up the sewage, a sluice gate was placed in the sewer and a 5-inch centrifugal pump installed to take care of the discharge of a 36 by 54-inch brick sewer of the combined type. In order to complete conditions favorable for polluting the water, a small brick cistern was constructed around the well casing of one of the wells, and an overflow laid to the sewer just below the sluice gate.

The river reached a very high stage, and began to back up the sewer. There was a heavy rain. Nevertheless the sluice gate on the sewer was closed, the ash discharge pipe plugged, and the 5-inch pump started up. There was no record of the 18-inch connection between the sewer and pump suction and the men in charge did not know that such a thing existed.

The surplus sewage over what the little pump could care for had but one outlet, that was back through the suction main into the

cistern around the well and then through its overflow to the lower side of the sluice gate. Thus a mixture of sewage and water was discharged into the mains and passed on to the consumers.

This pollution resulted in between 4000 and 6000 cases of diarrhoea, 417 cases of typhoid and 35 deaths. The city officials realized the seriousness of the legal situation confronting them, and engaged the best legal talent available to assist the city attorney. If the city should be held liable the resulting claims might amount to as much as $10,000,000, while the total valuation of the city was but $4,000,000.

Fortunately for the city, the facts connected with infection of the water were not generally known; a number of explanations had been offered, but most of them were quite wide of the mark.

The uncertainties connected with the case made the majority of people very slow to start legal proceedings; there were, however, two cases started and many more waited to see how these fared in the courts before taking similar action. In the meantime, the city's legal advisers adopted every possible means of delaying proceedings, hoping in this way to postpone a decision until the period of limitation had expired, for, as one of the attorneys said, "If the facts ever get before a jury we stand no show whatever."

It had long been admitted that a private corporation was responsible for the character of the water furnished; but the general theory is that a municipality is exempt or immune from liabilities unless the statutes specifically state the contrary. The city demurred on the ground that they were exercising a government function and were not engaged in a commercial enterprise and were, therefore, exempt from all liability. The District Court held for the city; the case was taken to the Supreme Court, which reversed the District Court. The city then asked that the case be opened for re-argument, which petition was denied. In the meantime, the period of limitation had expired. The city, therefore, settled the two cases, thus ending the litigation without trial on their merits.

As to the general rule of immunity, the Supreme Court said:

Defendant's argument would have had much more weight, if it had referred the court to a single case in which, under like circumstances, the rule of immunity had applied. This defendant has failed to do and we believe for the perfectly good and natural reason that there is no such authority. Certainly Hughes vs. Auburn, 161 N. Y. 96 . . . . to which defendant now calls our attention, is not an authority; to the contrary, this case did

not involve liability in the conduct of water works at all. The cases concerning the inadequacy of water supply for fire departments, it is perfectly obvious, involve essentially different circumstances from those presented by the case at bar.

As to the city exercising a government function in operating a waterworks, the court quoted from the dissenting opinion of Judge Elliott in a case where East Grand Forks sought to collect the water bills of a tenant from the owner of the property:

When the municipality enters the field of ordinary private business, it does not exercise governmental powers. Its purpose is not to govern the inhabitants but to make for them and itself private benefit. As far as the nature of powers exercised is concerned, it is immaterial whether the city owns the plant and sells the water, or contracts for a private corporation to supply the water. It is not in either case exercising a municipal function. When a municipality engages in a private enterprise for profit, it should have the same rights and be subject to the same liabilities as a private corporation or individuals.

The court said further:

It is obvious that a sound policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water. Nor does it appear why citizens should be deprived of the stimulating effects of the fear of liability on the energy and care of its officials; nor why a city should be exempt from liability while a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged.

In denying the application for re-argument, the court made the following statement:

The decision rested in effect upon this supreme consideration, namely, that public policy requires the conservation of human life, the preservation of public health and the establishment of public sanitation on a firm and certain basis in the law.

Section 8787 of the General Statutes reads as follows:

Every owner, agent, manager, operator, or any one having charge of waterworks, furnishing water for public or private use, who knowingly permits the appliances of the same to become in a filthy condition, or in such condition that the purity and healthfulness of the water supplied by reason thereof becomes impaired, shall be guilty of a felony, and punished by imprisonment in the state prison for not more than ten years.

It will thus be noticed that while the Supreme Court in the Mankato case establishes the fact that a municipality may be held responsible for the purity of its water supply, the state law would hold the municipal officers personally responsible.

The trouble at Mankato was purely an accident, resulting from general carelessness and intrusting administrative details to incompetent supervision. However, one must admit that the court's decision is based on the fundamental principle of right and justice.

One can conceive of a great many cases differing slightly from the Mankato case, but where the general principle is much the same; for example, the emergency intake where polluted water may be used for the purpose of extinguishing fires. The principal difference here is that contamination of the supply is deliberately arranged for, and life and health risks are assumed in order to reduce fire risk at the lowest possible cost. The same is true of the so-called dual connection at industrial plants. And it would seem that in either case not only does the municipality become subject to claims because of resulting sickness, but the officials also become personally responsible. Surely, if consideration is to be shown, a case such as that at Mankato, where there was no deliberate action or knowledge that risks were being assumed, would be given the preference over deliberate action and full knowledge that risks were being assumed for pecuniary reasons.

One thing the Supreme Court seemed to emphasize was that a municipality in extinguishing fires is exercising its police powers and cannot be held responsible for an inadequate water supply; therefore, if an official should be confronted with the alternative of polluting the water supply or furnishing an inadequate supply for fire purposes, he might be held legally responsible in the former case but not in the latter.

Then again we have the case where the source of supply is badly polluted, but due to a lack of appreciation of such conditions on the part of the people, the water continues to be used.

The author's legal friends seem to be of the opinion that a community, in voting in favor of such a supply, does not necessarily incur responsibility, inasmuch as in exercising their rights of franchise they are not acting as a responsible body although there is a possibility that officials in carrying out the will of the people as expressed at an election become responsible, as they do constitute a responsible body.

Section 8759 of the Minnesota General Statutes, defining a public nuisance, reads in part as follows:

A public nuisance is a crime against the order and economy of the State, and consists in unlawfully doing an act or omitting to perform a duty, which act or omission:

1. Shall annoy, injure, or endanger the safety, health, comfort, or repose of any considerable number of persons;
2. Shall offend public decency;
3. * * * *
4. Shall in any way render a considerable number of persons insecure in life or the use of property.

In all of the three preceding cases, when there is knowledge that pollution exists, or that risks of pollution have been assumed, it seems reasonable to the author's mind to say that it constitutes a public nuisance, inasmuch as they all endanger the safety, health, comfort, or repose of a considerable number of persons; and it certainly does offend public decency to think that the public must assume the risk of drinking contaminated water, in order that the cost of fire insurance risks may be reduced in a few cases.

The legal responsibility for a pure water supply is a very important matter and worthy of careful consideration by a man of legal training and wide professional experience; and the author regrets very much his incapacity to do the matter justice.

DISCUSSION

J. C. Flanagan: The writer has carefully scrutinized the laws of Minnesota with respect to this subject, and also has consulted with members of the Legal Department of the City of St. Paul relative to the matter. He finds that where a charter is granted to a water company, it has a legal right to lay its pipes and mains in the streets of the city or town where such charter is granted. Such right cannot be denied by the municipality, nor is it necessary to obtain its permission, and this applies not only to the municipality which is to be supplied with water, but also to the laying of mains in the streets of a city or town which is situated between the source of supply and the city to be served.

There is usually a requirement in the contract for the granting of a charter, that the water company shall furnish an "ample supply" of

water for "first class fire protection," and also that the company furnish an adequate supply of "pure and wholesome" water, which means water which is ordinarily and reasonably pure and wholesome and fit for domestic use, and not necessarily that it should be chemically pure, but if the water does not conform to this standard, the company will be precluded from collecting rentals either from the municipality or private consumers, and may be liable in damages to persons injured by reason of impurity.

The laws of this state provide that either a municipality or a private citizen having a definite contract with a water company for a supply of water may maintain an action for damages resulting from the failure or insufficiency of the supply, unless caused by unavoidable accident without the company's negligence or fault. Several decisions have been rendered sustaining this rule in many of the States, although none apply to the State of Minnesota.

The laws presume, also, that a water company is liable in damages if its negligence in the construction or maintenance of its dams and reservoirs permits the leakage or escape of water so as to injure the property of others, or if it so pollutes or fouls the stream as to render it unfit for use by others having rights in it.

The water company must recognize the right of a riparian owner and see that streams which flow through or by his premises remain in their natural condition of purity, and free from any such contamination or pollution as renders them unfit for his domestic purposes, and he is under no duty to protect himself from injury through pollution at his own cost. The company may, however, prevent a riparian owner from using the water for bathing purposes, or from maintaining a large herd of cattle, cow-stables, hog-sties or a slaughterhouse on the banks of the stream, which might tend to pollute the water, and for injuries sustained from such pollution the water company might be found to be liable.

A water company or a city operating a waterworks plant has the right to make and enforce reasonable rules and regulations governing the supply of water to its customers and their use thereof, such as regulations to prevent the waste of water, or its use by persons who do not pay for it, and rules respecting the style and installation of plumbing, hydrants and other appliances, and the cost of connections and repairs, or providing that no more than a certain quantity of water per diem shall be used in any building without a special permit, or reasonably restricting the use of water for sprinkling the streets.

Therefore, it is clear that the water company is legally bound to so construct its plant as to prevent, in any way, surface waters overflowing from streams or rivers from entering its service. It also has been given, by competent counsel, that where a water company, in the construction of its plant, protects same against intermittent events, it could not be held liable for damage resulting from an unforeseen or unanticipated condition which might cause pollution.

The writer is of the opinion that a water company or a municipality which would grant the right to permit water to be connected to the domestic supply from a polluted source (in other words, a dual supply) for the purpose of fire protection, would and could be held responsible for any damages resulting from pollution of the water by reason of such act, and therefore it should be considered against good policy, and a legal risk, to grant such permission, even though numerous valves might be placed upon such connection with the view of preventing the injection of polluted water into the water supply. These valves, at the best, are mechanical contrivances and bound to go out of order, and, as already stated, the water company or municipality granting such permission, assumes a tremendous legal responsibility to the users of the water and should be restrained from granting such permission, especially in view of the fact that in addition to not complying with the terms of the franchise granting it the right to supply "pure and wholesome" water, it creates a legal hazard which might operate to its disadvantage.

POLLUTION OF NIAGARA RIVER BY WASH WATER FROM FILTRATION PLANT ENJOINED[1]

On May 27, 1919, the Court of Appeals of the State of New York confirmed a decision of the Supreme Court of Niagara County, made in July, 1915, in an unusual suit to restrain the pollution of water. This was an action to prevent pollution brought by a water company against a public water board, and the pollution in question was due to the discharge of waste and wash water from a water filtration plant. The original decision having been confirmed by the higher courts becomes binding, and the following extracts from it state the facts, as determined by the court, and the reasons for its decree:

This is a suit in equity to enjoin the City of Niagara Falls and its Board of Water Commissioners from discharging the waste effluent from the municipal filtration plant into the Niagara River above the intake of the Niagara Falls Power Company, from which, as lessee, the Western New York Water Company, receives and distributes water for drinking and other domestic uses to a large number of the inhabitants of the city of Niagara Falls.

The plaintiff has a franchise from the New York Legislature and from the former Village of Niagara Falls to supply the inhabitants of the village with wholesome water, and the source of its supply is designated in its franchise from the village as the Niagara River. The plaintiff is also the lessee and in possession of lands on the bank of the river, under riparian owners, and as such is entitled to the rights of a riparian owner with respect to the waters of the river. (See Rathbone vs. McConnell, 20 Barb. 311, affmd. 21 N. Y. 466; Bly vs. Edison Elec. Ill. Co., 172 N. Y. 1). The defendants also maintain a water plant for supplying other inhabitants of Niagara Falls with water and take water from the river some two miles above the plaintiff's intake. The defendants take the water from a point

[1] **Court decisions furnished by Harry F. Huy, General Manager, Western New York Water Company, Buffalo, N. Y. Attorneys for Water Company, Kenefick, Cook, Mitchell & Bass, of Buffalo, represented by Ed. H. Letchworth. Discussion of this paper is requested and should be sent to the Editor.**

some 2000 feet out in the river and take it into a filtration plant on the bank, which it constructed in 1912, and there the water passes through the filter and substantially all of the impurities are separated from the water and the pure water passes into the service mains and pipes of the city's plant for the use of its consumers. A large quantity of this filtered water is used daily to wash the filter beds, and all the bacteria and other impurities which have been taken from the raw water in the process of filtration are discharged into the river near the bank.

The evidence tends to show that the quantity of this discharge from the filter beds for the year 1914 was 95,176,800 gallons, or an average of about 260,000 gallons per day, and that the average amount of suspended matter, not including solids in solution, in this effluent from the filter beds, was from 4.56 tons to 8.9 tons per million gallons, and that the defendants also discharge into the river at the same point from ten to twelve times per annum about a million gallons, the contents of each of two sedimentation basins connected with its filtration plant, consisting of bacteria and other impurities separated from the raw water, together with the chemicals added thereto by the defendants, and that the average amount of suspended matter, not including solids in solution, in this discharge is $22\frac{25}{27}$ tons per million gallons, and that from the sedimentation basins alone there is probably discharged into the river annually approximately 550 tons of suspended matter. The defendants add from 125 to 200 pounds of hypochloride, including 30 or 40 pounds of lime, which tends to increase the hardness of the water, to each sedimentation basin before discharging the contents thereof into the river; and it appears that a less quantity of hypochloride would render the water unpotable. The defendants also add 20 pounds of hypochloride per million gallons to the water used in washing the filter beds. In this manner approximately three tons of hypochloride are discharged in the effluent into the river annually by the defendants. It further appears that about 300 tons of aluminum sulphate are added to the water annually in the coagulating basins at the filtration plant of the defendants and in the effluent discharged into the river. It thus appears that about five-sixths of a ton of chemical matter is discharged into the river daily on an average by the defendants in the operation of its filtration plant.

The currents of the river from the point of this discharge to the plaintiff's intake are toward or along the bank, and the flow of the

current is upwards of one mile per hour. The average amount of suspended matter in the water at the plaintiff's intake is from two-fifths to one-half ton per million gallons. The plaintiff is obliged to maintain a filtration plant to separate this suspended matter from the water before delivering the water to its consumers, and the greater the amount of suspended matter, and particularly the greater the percentage of bacteria, the greater the expense, care and effort required in insuring the wholesomeness of the water furnished to consumers. The effluent discharged from the filtration plant of the defendants is highly colored and gives out a strong and offensive odor. It is true, that with the exception of the chemicals, which, as stated, are added in the process of filtration, all of the impurities in this effluent have been taken from the river; but they have been taken so far from the bank that it is fairly to be inferred that none of them would have entered the intake of the plaintiff, and, moreover, they are discharged in this concentrated form. The waters of the river are otherwise largely polluted, both above and below the filtration plant of the defendants, and it is impossible to determine with any degree of definiteness the proportion of the entire pollution caused by the defendants; but it is fairly to be inferred that some of the pollution of the water from which plaintiff takes its supply is caused by this discharge of the effluent from the filtration plant of the defendants.

There is a trunk sewer in Buffalo Avenue adjacent to the filtration plant of the defendants into which the effluent from the filtration plant could be discharged as conveniently and with no greater expense than into the river, for the bed of the sewer is upwards of 2 feet lower than the average level of the water in the river at the point of discharge. It is necessary to use pumps, which are installed for that purpose, to completely drain the sedimentation basins through the discharge into the river, and the use of the pumps would not be required to as great an extent to drain the sedimentation basins into the sewer, from which the contents could lawfully be discharged into the river below the falls.

The principal material conflict in the evidence is between the chemists called by the respective parties, and in determining the issues presented by such conflict the court accepts the testimony of the chemists called by the plaintiff, not, however, upon the theory that the witnesses for the defendants are not entitled to credit, but upon the ground that the witnesses for the plaintiff have

had greater experience and their tests were shown to be more reliable in that they tested the acidity of the gelatine with which their tests were made, and all of the samples taken by them were produced in court and their appearance tends to disprove the theory of the defendants that the effluent which they discharged into the river is more free from contamination and pollution than the raw water of the river into which it is discharged, and that in the main the conflict is owing to the difference in the circumstances with respect to the time and place of taking and the method of identifying and preserving the samples of the water of the river and of the effluent for the tests, and particularly with respect to the stage of the operation of the filtration plant at the time of the taking of such samples.

The competition between the plaintiff and the defendants in supplying the inhabitants of the city with water has resulted in more or less friction. It is claimed on the part of the defendants that this suit and other actions were brought by the plaintiff for the purpose of coercing the defendants into purchasing the plaintiff's plant and franchise; and on the other hand the plaintiff claims that it is at a disadvantage in retaining and obtaining customers for water, owing to the fact that the defendants are in a position to say and do give publicity to the fact that they are discharging the impurities which they take from the water into the river and that the water taken by the plaintiff is injuriously affected thereby. In the circumstances, it is not improbable that there may have been some foundation for these charges and countercharges, but they have not been proved, and there is nothing before the Court to warrant a finding that the plaintiff has brought this action for an ulterior purpose or that either party is acting in bad faith.

The question presented for decision by these facts is whether the plaintiff is entitled to have the defendants enjoined from discharging the effluent from their filtration plant into the river, and leave it to them to provide another outlet therefor through the sewer in Buffalo Avenue or otherwise. Of recent years courts have frequently been called upon to adjudicate concerning the rights of riparian owners with respect to the waters of natural freshwater lakes and streams, and the established rule is that while riparian owners do not own the water, each is entitled to a reasonable use thereof, which depends upon the particular facts and circumstances of the case, but must not thereby materially lessen the quantity

or alter the quality of the water flowing by his premises, and that these are property rights, protected by the Constitution, of which the owner may not be deprived without just compensation, and if there be no adequate remedy at law without multiplicity of suits or there be danger that the unreasonable use will ripen into a prescriptive right, a court of equity will afford relief by injunction. (Strobel vs. Kerr Salt Co., 164 N. Y. 303; City of New York vs. Blum, 208 N. Y. 237; Butler vs. Village of White Plains, 59 A. D., 30; Mann vs. Willey, 51 A. D. 169, affmd. 168 N. Y. 664; Huffmire vs. City of Brooklyn, 162 N. Y. 584; Sammons vs. City of Gloversville, 34 Misc., 459, affmd. 67 A. D., 628 and 175 N. Y. 346, id. 81, A. D. 332; Chapman vs. City of Rochester, 110 N. Y. 273; Moody vs. Village of Saratoga Springs, 17 A. D., 207 affmd. on opinion below, 163 N. Y. 581; Seifert vs. City of Brooklyn, 101 N. Y. 136; N. Y. Rubber Co. vs. Rothery, 132 N. Y. 293, 296; Bolton vs. Village of New Rochelle, 84 Hun 281; Stoddard vs. Village of Saratoga Springs, 127 N. Y. 261.) As illustrating the rule with respect to the reasonableness of the use of the water, the court quotes from the opinion of the Court of Appeals in City of New York vs. Blum, supra, as follows:

> The question in a nutshell is whether it is reasonable for the defendant to divert the water from the natural channel and to return it, laden with excreta of his domestic animals, when he can with slight trouble prevent such pollution. It is unimportant that those animals happen to be ducks. The plaintiff does not seek to prevent the defendant from raising ducks. It merely asks that he shall conduct that business with some regard to the rights of others. He can allow the ducks to have access to the ponds and by a little labor prevent the pollution of the waters of the stream.

The acts of the defendants are in the nature of continuing trespasses for which an action at law does not afford an adequate remedy, and while ordinarily equity does not intervene to prevent the infliction of merely nominal damages, that rule does not apply to the case at bar for the reason that in such case nominal damages are deemed substantial, and, moreover, it is evident that there are substantial damages, but it is impossible to show them with a sufficient degree of certainty to warrant a recovery, and it is not even essential to the maintenance of an action for pollution that damages shall have been suffered if the plaintiff's rights have been invaded and there is danger that such invasion may ripen into a prescriptive right, as there is in the case at bar. (Mann vs. Willey, supra;

Amsterdam Kniting Co., vs. Dean, 162 N. Y. 278; Strobel vs. Kerr Salt Co., supra; Townsend vs. Bell, 62 Hun 306; N. Y. Rubber vs. Rothery, supra.)

It was first contended in behalf of the defendants that the discharge from their filtration plant into the river was authorized by the approval of the plans for the construction of the filtration plant by the State Board of Water Supply, but they were unable to show the approval of the plans providing for the discharge of the waste effluent into the river or a certificate from the State Board of Health therefor, as is expressly required by the provisions of Section 76 of the Public Health Law in order to authorize such discharge; and they have also failed to show a permit from the Secretary of War, as required by the provisions of Section 13 of the Act of Congress of March 3, 1899 (30 U. S. Statutes-at-Large, 1152), which renders such discharge into navigable waters, which the waters of the Niagara River are, unlawful without such permit. The defendants, finally, on the submission of the case, claim that if their acts are unlawful they cannot ripen into a prescriptive right and that therefore there is no basis for injunctive relief. The court agrees with the learned counsel for the defendants that acts in express violation of law cannot give rise to a prescriptive right. (See Brookline vs. MacIntosh, 133 Mass. 215; People vs. Pelton, 36 A. D. 450, affmd. 159 N. Y. 537.) But, as already stated, aside from the question of acquiring a right by prescription there is a basis for equitable jurisdiction, and moreover, it is possible, although not probable, that permits may be obtained at any time from the State Commissioner of Health and from the Secretary of War, which would remove the statutory prohibitions.

There is no force in the contention that the action cannot be sustained without joining all parties who are contributing to the pollution of the river, and that since the water is so polluted by others that even if the discharge of the waste effluent from the filtration plant of the defendants were stopped, still the plaintiff would be required to filter the water, as doubtless it would. If the plaintiff were seeking to recover damages the extent of the pollution by others would have a material bearing for defendants would only be liable for the damages caused by themselves; but otherwise these contentions have been frequently made in principle and overruled. (Semmons vs. City of Gloversville, supra; Chapman vs. Palmer, 77 N. Y. 51, 56; Strobel vs. Kerr Salt Co., supra;

Butler vs. Village of White Plains, supra; Whalen vs. Union Bag & Paper Co., 208 N. Y. 1.) Where, as here, the pollution by the defendant is in violation of express statutory provisions, less evidence of contamination is required to warrant an injunction in favor of one entitled to use the water, as is the plaintiff. The city of Niagara Falls is rapidly increasing in population and the contamination of the river by this effluent from the filtration plant of the defendants will naturally be more and more. Without, therefore, expressing an opinion with respect to the right of the plaintiff to injunctive relief against others who are polluting the waters of the river, it is proper that a court of equity should enjoin a municipality, which is engaged itself in supplying part of its inhabitants with water, from unnecessarily contaminating and polluting the water from which the plaintiff takes its supply for others of the inhabitants of the city, and especially since it is evident that another outlet for the effluent from the filtration plant is available at a very small expenditure. The defendants, however, should have a reasonable time to enable them to construct another outlet.

There is no merit in the further contention that the merger of the Niagara Falls Water Works Company with the plaintiff was invalid on the ground that the merger was unauthorized in that the plaintiff's plant and franchise were in the town of Cheektowaga, Erie County, some 20 miles distant from those of the Niagara Falls Water Works Company. That point was presented in another action by the plaintiff against the defendants in which a temporary injunction order was issued for the protection of the plaintiff's rights at Niagara Falls, and that order was sustained, which must have been upon the theory that the merger with the plaintiff was lawful, or at least was not open to question by the defendants. (158 A. D. 955, Case and points, 4th Sept. Buffalo Law Library, Vol. 1201.) Moreover, the plaintiff has since the merger in 1909 exercised the franchises of the Niagara Falls Water Works Company, and the people of the state only may question the validity of the merger. The plaintiff did not present a formal complaint or call upon the defendants to provide another outlet for the discharge from their filtration plant before bringing the action, and in the circumstances no costs should be allowed.

Let judgment be entered accordingly enjoining defendants during the continuance of plaintiff's leasehold and franchise rights from

discharging the effluent from their filtration plant into Niagara River, but with a provision to the effect that it shall be suspended for the period of six months to enable defendants to provide another outlet, and with leave to defendants to apply at special term, if necessary, for an extension of such period of suspension if, for insufficiency of appropriation of funds or other cause, they shall require further time.

OZONE AS A DISINFECTANT IN WATER PURIFICATION[1]

By Joseph W. Ellms[2]

Ozone was first observed by the Dutch chemist Van Marum in 1785, while operating a static electrical machine. In 1840, Schoenbein while investigating the properties of the gases produced in electrolyzing water and electrifying air, noted the odor and oxidizing properties of the gas and gave it the name of "ozone," because of its peculiar odor. It was not until the results of Soret's work in 1865 were known, that scientists agreed that ozone was tri-atomic oxygen, although it had been generally held that it was some form of oxygen.

Ozone is an unstable gas requiring a large amount of energy for its formation (34,000 calories). It is but slightly soluble in water, and undergoes decomposition when heated. When strongly ozonized oxygen is liquefied and the product subjected to fractional distillation, a mixture of ozone and oxygen results, of which about 85 per cent is ozone. The factors governing the "ozone-oxygen system" are none too well understood. The state of equilibrium which exists in a mixture of the two gases is dependent upon several factors, such as temperature, pressure, and electrical conditions that are extremely complex.

Ozone is an extremely energetic oxidizing agent. It attacks many inorganic oxidizable substances readily, and is particularly destructive of organic matter even at low temperatures. Its value as a bactericidal agent is probably due to this property, and is the reason for its use in the disinfection of drinking water.

For practical purposes, the production of ozone can best be effected by certain forms of electrical discharges through oxygen gas or through air, which, of course, consists in part of oxygen. It may be well to describe the nature of these discharges so that the technical difficulties of the practical production of ozone will be better appreciated.

[1] Read before the Central States Section. Discussions of this paper are requested, and should be sent to the Editor.

[2] Consulting Sanitary Engineer, Cleveland, Ohio.

The phenomena of an electrical discharge through a gas are complicated. Ordinarily gases are non-conductors, but may become conductors under certain physical and electrical conditions brought about by the flow of the current through them. When two electrodes are separated by a gas and connected to some source of high tension electricity, and between them the potential difference is being gradually increased, there is first produced an invisible electrical discharge which gradually becomes visible by a glow upon one of the electrodes. As the potential difference increases the corona effect is produced, which changes to the true brush discharge. It is this latter form of discharge that is regarded as the most effective in the production of ozone. By still further increasing the potential difference between the electrodes there is formed in succession the spark discharge, the flame and finally the well known electric arc.

The brush discharge is of a dark blue violet color and is accompanied by a peculiar hissing sound and the "electric wind," which latter, according to J. J. Thomson, is due to a current of electrified ions that set the air in the vicinity of the discharge in motion. Brush discharges are readily formed on electrodes having sharp points or roughened edges. Alternating or direct current may be used, but usually the alternating current is preferable since it may be obtained more readily under high tension. A better production of ozone appears to be obtained with alternating currents of high frequency. A 500 cycle alternating current is more commonly used in ozone installations than one with lower frequencies.

It has been found, as a result of much experimentation, that the use of a dielectric between the electrodes increases the yield of ozone. In other words, imposing even greater resistance than that offered by the air itself, effects a larger production of ozone by the discharge. Dielectrics are made from various substances, such as glass, mica, fused quartz and baekelite. While many other substances will act as dielectrics, the above named include the practical materials available in ozone work.

It will probable be appreciated from the little that has been cited of the complex character of the phenomena of ozone production that the pressure, temperature and humidity of the air being electrified, the form, size, spacing and material of the electrodes, the kind of current employed, the frequency in the case of an alternating current, the voltage, amperage and other secondary influences of an

electrical nature in general, and the kind and arrangement of the dielectrics employed, are factors that must all be given careful consideration in an efficient ozone apparatus. A brief description of one or two of the ozonizers that have been developed and have been used may be of interest.

There are two general types of ozone apparatus. The Siemens-Halske ozonizers are of the vacuum tube type, in which air is drawn through an annular space across which high-tension electrical discharges occur. An inside metallic cylinder acts as one electrode. It is covered by a slightly larger tube of glass covered with tin foil. The electrodes are water cooled. The General Electric and the Gerard apparatus are of the tube type also. The Small-Linder, Abraham-Marmier and Vosmaer apparatus use plate forms of electrodes and dielectrics. In some cases their electrodes are hollow and water cooled, but in others this cooling is not attempted. Voltages varying from 2000 or 3000 to 50,000 or 60,000 have been used in various ozonizers, but from 10,000 to 20,000 volts are more commonly employed. The yield of ozone increases with an increase in wattage for any given area of electrodes, that is, with the density of the current per unit of area.

The application of the ozonized air to water, where the ozone is to act as a disinfecting agent, has been given considerable attention by investigators, but much more study of the problem is needed. In some cases the flowing water is used to suck the ozonized air through the ozone generator and into the water to be treated. This method is not susceptible of very close control. Another method consists in pumping the ozonized air into the bottom of towers down through which the water descends. A modification of this latter method consists in placing the air compressor back of the ozonizer, thereby avoiding handling the corrosive gas in the compressor. In this case the ozonizer must be in a container that will withstand the air pressure required to overcome the hydrostatic head of the water columns and the friction head resulting from the flow of the air through pipes and towers. A third but expensive method has been used in which the water has been sprayed into the atmosphere of ozonized air. Baffled towers where the counter-current system is used have not proven very successful. A great deal is yet to be learned regarding the proper method of distributing the ozonized air at the bottom of the column of water, so that a maximum absorption of ozone may be effected.

Since the expenditure of so much electrical energy in ozonizing the air creates more or less heat, and in consequence subsequent decomposition of the ozone formed, cooling and drying the air by refrigeration have been usually resorted to.

In small plants, passing the air over chemicals that would absorb the moisture, has also been successfully utilized. The yield of ozone apparatus naturally varies greatly, depending upon the manner in which the air is handled both before, during and after the passage of the gas through the ozonizer. Russell Spaulding in a report to the New York State Department of Health in 1913, very concisely states the desirable features of a good ozonizing apparatus. He estimates the theoretical yield of ozone for an expenditure of 1 kilowatt of electrical energy to be 1386 grams. Since the actual yields of apparatus will vary all the way from 10 to 60 grams per kilowatt, it is evident that their efficiencies are very low. Mr. Spaulding summarizes his conclusions as follows:

> To summarize, then, the main desiderata in generating ozone are:
> 1. A supply of alternating electric current at low cost.
> 2. An efficient transformer to obtain high tension.
> 3. Ozone electrodes that *do not* generate heat to
>   *a*. Disrupt the dielectrics.
>   *b*. Cause reversion of ozone to oxygen.
>   *c*. Require external means for cooling.
> 4. Ozone electrodes that will approach the theoretical efficiency much more closely than the various systems now in use.

To this the author would add, that unless the ozonized air is effectively applied to the water to be disinfected, that is, unless practically 100 per cent absorption of the ozone by the water is effected, the over-all efficiency of the entire apparatus may still be far from satisfactory. This phase of the subject still warrants considerable investigation.

The ability of ozone to reduce the bacterial content of a water has been too frequently demonstrated to doubt its inherent disinfecting properties. Nevertheless, it has its limitations in this direction like other disinfectants. In waters containing too large an amount of organic matter some of the bacteria may escape being killed. Pathogenic organisms probably are more readily killed than the ordinary water forms, because of the unfavorable conditions imposed upon them in the water, as well as from the destructive effect of the disinfectant. Spore-forming bacteria may also escape

destruction. Ozone, because of its strong oxidizing powers, has the merit of being able to oxidize and remove tastes and odors due to organic matter in suspension or solution, and to reduce the color due to vegetable stain. If ferrous iron exists in a water, it is able to oxidize the iron to the ferric condition, in which form it is practically insoluble, and hence may be removed by sedimentation and filtration.

In conclusion, it may be well to point out that ozone used as a disinfecting agent is no more a cure-all for a polluted water supply than are other disinfecting agents that are at present more widely employed. As a supplement to filtration processes ozone can be used with good effect, and thereby render the water safer for drinking purposes. That the process needs investigation and scientific development in order to make it economical and efficient, cannot be denied by its most ardent advocates. When such a development is brought about, its use in the purification of water will become more general and its points of real merit better appreciated.

DAMAGE TO FIRE HYDRANTS BY MOTOR VEHICLES[1]

W. W. Brush: Damages to fire hydrants by motor vehicles and remedies for the trouble are becoming of increasing importance in all cities. In New York the damages of this nature have been increasing rapidly during the last two years. The number and size of motor vehicles on the streets are growing rapidly, and the drivers have not yet learned the limitations that must govern them if injury to pedestrians and damage to property are to be prevented.

Either trucks or passenger cars may strike objects above the sidewalk level which are placed inside the curb line, by skidding on wet pavement, by backing up to the curb, the overhang of a truck extending 2 or 3 feet beyond the curb line, or by intentionally driving up on the sidewalk. Practically anything inside the curb line will give way if hit by a 3-ton or 5-ton truck. The fire hydrant, which is usually located about 18 inches inside the curb, is most liable to be hit, as it cannot be readily seen by the driver who is backing his truck against the curb, and is also in a favorable position to be hit at the corner when a car skids in making the turn. During the past two years, New York has had on an average about 400 hydrants destroyed annually through being struck by motor vehicles, largely trucks.

Up to three or four years ago this trouble was of minor consequence, but with an annual destruction of 400 hydrants the repair bill amounts to $12,000 a year. Originally the Department replaced the hydrants or scrapped the damaged parts. The development of the process of electrical welding made it possible to have the standpipes welded, thus avoiding the loss involved in scrapping them. This work is done in the Department's shops for about $6 per standpipe, without any allowance for overhead; if the work is done in private shops the cost is $8 to $10. To weld the standpipe and assemble the hydrant in the Department's shops costs about $12.50. The cost of removing and replacing a hydrant, exclusive of its repair, is estimated at $20. The total outlay for 400

[1] Informal discussion at the Buffalo convention, June 10, 1919. Further discussion of this subject is requested and should be sent to the Editor.

hydrants therefore reaches the sum of $12,000, as previously stated. At first thought it may seem that some change is necessary in the type or location of the hydrant in order to avoid this expenditure, but when that expense is distributed over the 40,000 hydrants in New York the unit expense is reduced to an average of 30 cents per hydrant annually. This average cost for the entire number of hydrants should be increased to show the actual cost where the traffic is heaviest and decreased where it is lighter. In the Boroughs of Manhattan and the Bronx where the traffic is very heavy, the number of hydrants broken represents about 350 out of the total 400 broken annually in the entire city. In that area there are over 21,000 hydrants. The resultant average cost is 60 cents per year per hydrant.

The speaker knows of no preventive remedy that can be employed at a reasonable cost. Cases are rare in New York when the escaping water from a broken hydrant causes the serious damages reported from other cities. When a hydrant standpipe is broken it is simply a question of repairs, as a rule, and the loss of water is negligible. In one instance a high-pressure hydrant placed in a vault recess was broken below the valve of the hydrant. The water blew in a property wall of a large office building back of the hydrant and caused many thousands of dollars damage. Engineers of cities using a type of hydrant which opens with the pressure report that they have had serious difficulty from damages due to water escaping from broken hydrants of that type. This trouble has been reported as particularly serious at Boston, where it led to a change in the type of hydrant.

The thickness of the wall of the hydrant seems to have little effect upon the resistance to breakage by impact with a truck. Hydrants protected by fenders have been broken, so the speaker doubts if there is any effective protection against heavy trucks. Welding the broken parts seems to be the cheapest solution of the trouble in New York at present. The welding is done by the oxy-acetylene process but the electrical process will doubtless do as good work. The broken hydrant is taken to the shop, the broken section cut away at a bevel of about 45 degrees and new metal is fused on at the break. If the portion of the hydrant thus treated is to be exposed above ground, it is finished off after the welding is completed, but if the weld is buried in the ground the surface of the metal is left rough.

Where any damage results to private property from a hydrant broken in the manner under consideration, the city is not held responsible provided it has used reasonable diligence in shutting off the water after the hydrant was broken.

F. W. Cappelen: The subject of damage to fire hydrants by motor vehicles is apparently as important in other cities as in Minneapolis. There the various propositions suggested as remedies for the troubles have all been considered without arriving at any definite conclusions.

Minneapolis is fortunate in having in use only the compression-type hydrant. In only one case of breakage was there any loss of water with resulting damage. This was due to the fact that the hydrant was set in a brick well, so that it was free to give way to the shock. The post of the hydrant was broken into three pieces by the impact of the automobile and the branch was also broken between the hydrant valve and the main, thereby permitting the water to escape. This same hydrant was replaced by a Darling hydrant with a 9-inch post, set firmly in the ground. Being located at an angle in the street, it also was struck later, with no damage to the hydrant. The post withstood the shock while the occupants of the automobile had to send two of their number to the hospital.

The remedies that have been suggested are:

1. Move hydrants back from curb to building line.
2. Substitute flush hydrants for post hydrants.
3. Employment of fenders or guards.
4. Repair by welding and reset in present locations.

In discussing this matter it might be well to consider first the cause of the damage. Motor vehicles unavoidably, the drivers claim, collide with hydrants:

(a) By skidding on wet or slippery pavements.
(b) As the result of collision of two or more vehicles.
(c) Speeding around a curve, or corner.
(d) Trucks backing into hydrants.

The records at Minneapolis show that only one hydrant has been broken which was not located at a street intersection but midway in the block. This hydrant was located in the wholesale district, where a truck attempted to turn around in the middle of the block and backed into the hydrant mentioned, thereby causing the damage.

Cases of collision and skidding generally occur at the intersection of streets and are due to the misunderstanding of the drivers as to the intent of others. This results in smash-ups or the forcing of one or the other of the meeting vehicles over the curb. If a hydrant is in the way, it is at once the victim and suffers damage. It has also been noted that many of the accidents are marked by evidences of considerable force so that in order to resist shock hydrants or other objects for that matter must have considerable strength.

There are certain street intersections which are exceptionally dangerous. Minneapolis has certain places where broken hydrants are "repeaters;" the hydrant on a certain corner has been broken four times in succession and at another location the damage has occurred twice.

Four remedies are offered, as follows:

1. It has been suggested that hydrants be set back from the curb and close to the building line. It is not considered good practice to set hydrants close to a building, which itself might become a fire victim thereby rendering the hydrant useless. Unless the hydrant was set back to some point inside the walk, it would probably not be safe from damage, as vehicles crossing the curb would cause the same injury as though the hydrant had been located directly at the curb. Also, in the down-town district where most of the accidents of this nature occur, the area-ways under the sidewalk would preclude the moving of the hydrant in this direction. A further objection would be the inaccessibility of such hydrants to the fire engines, and the risk of having them too close to the buildings.

2. The use of flush hydrants or hydrants under cover and grade might be a solution in warm climates, but unless marked by some kind of post, which in turn would be in danger of being struck, it would be difficult to locate flush hydrants quickly under snow and ice. Frozen covers would delay their use and the inconvenience of connecting to such hydrants would cause them to be very unpopular with fire departments. As a matter of fact, Minneapolis had about 24 such hydrants which were replaced by post hydrants for the reasons stated. While the use of flush hydrants might overcome the trouble, the expense of making the change would be enormous, and while it would be unnecessary to change all hydrants, the use of two kinds would prove confusing, particularly in an emergency. The principal objection to flush hydrants in cold climates is the annoyance of having the pit fill with slush and water and freeze solid at a conflagration of several hours' duration.

3. Experience at Minneapolis with hydrant guards shows that they are not very effective. Hydrants have been broken off where 6-inch pipes have been set in the ground to protect them. Not only have the hydrants been broken but the guards themselves were broken by the shock. Guards or fenders would have to be very substantial to be effective and would thereby prove undesirable obstructions, not only to traffic but also to the fire department's use of the hydrants. Guards will also involve considerable expense, and if there is any doubt as to the effectiveness of their use the expenditure for them is not justified.

4. Minneapolis has followed the practice of repairing the hydrants thus broken by welding whenever possible and replacing them in their former locations. Occasionally a hydrant is broken beyond repair, but generally they can be mended. During the past 15 months there have been 43 hydrants broken in Minneapolis. The average expense per hydrant has been as follows:

Excavation, removal and resetting	$14.40
Shop work and assembling	3.84
Welding (done by private concerns)	10.47
Cartage	2.50
Total	$31.21

In but very few cases is the city able to collect damages for breakage. It is necessary to get proper evidence and then it must be shown that the drivers were careless, negligent or malicious. In some cases, where a firm's truck is found on the wreck, the owners will pay.

The 5-inch Mathews hydrant is very susceptible to breakage, especially if it is located in a brick well which allows some freedom of movement. A hydrant without jacket set in the ground will resist a considerable blow and in some cases a 7-inch post will be pushed over somewhat without breaking. This suggests the advisability of using hydrants with a large, strong barrel or post set firmly in the ground. Such hydrants should be of the compression type.

If anything further is to be added to this question, it is to call attention to the natural inference from the fact that no less than 95 per cent of the breakage is done at street intersections, namely, to avoid setting hydrants in the danger zone. If hydrants are to be moved at all they should be moved away from the corner and set at a distance of a lot or two lots away from the line of the inter-

secting street. They could be located on the lot line where they would be less obstruction than at the corner.

The only reason for setting hydrants at corners, is to permit running hose lines down either intersecting street. With the short removal from the corner suggested, this can still be done with almost equal facility and less danger. The proximity to fires would be the same in either case, and when streets are fully gridironed by water mains, there is really nothing but custom that calls for the corner location. Now that this new menace has appeared it would seem that custom would have to give way to practical requirements. This solution would be a modification of the first suggestion, i.e., to move the hydrant, not back, but away from the corner.

Richard Whitney: The particular type of damage under consideration has not occurred often enough in Syracuse, N. Y., to be thought of as a very serious problem. Although the water department has no special record of such accidents and the repairs incidental thereto, the number of such accidents which occur per annum does not exceed ten, and is probably much less than that number. In the system of nearly 4,000 hydrants, that makes the percentage damaged by this cause per annum about one-fourth of one per cent. There has never been any flood condition from an accident of this kind.

One particular hydrant in the system has been broken off three times in the past two years and has now been moved back from the curb as far as practicable. This hydrant is at an intersection of a wide and a narrow street, where the great volume of traffic turns from the wide to the narrow street. If the hydrant were placed on the opposite corner, the trouble would be largely, if not entirely, eliminated.

Of all accidents upon which reliable information is available, all but two were caused by pleasure cars. The drivers either lose control of the car, fail to judge the turn correctly, or are forced to jump the curb to avoid a more serious accident. One truck driver when ascending a steep hill, found that he was unable to reach the top and the brakes would not hold. He thereupon steered backward for a hydrant, with the hope that it would arrest his precipitous progress. The result can be easily imagined.

The Syracuse practice has been to repair the old hydrant or reset a new one and where practicable to move it farther away from

the curb. The broken parts of the hydrant can usually be welded. The expense involved is borne by the one who causes the damage, when it is possible to get this information, and averages not far from \$55.00 for each offense. The department expects to continue this practice. The expense entailed in changing to a different type of hydrant, as a flush hydrant, for instance, would not be warranted in Syracuse, where the total damage is so slight. The department hopes to study traffic conditions somewhat, in the future, in placing new hydrants and also to set at critical points hydrants which have the least tendency to open when broken.

A. W. Cuddeback: The number of hydrants broken in Paterson, N. J., is about the same percentage as in Brooklyn, N. Y. About half of the injured compression hydrants break off down near the valve. It does not seem feasible to consider a general change in the location of hydrants. The speaker has not found that hydrants opening with pressure are any more liable than other types to cause damage through flooding. In practically all cases, the Passaic Water Company has been successful in fixing the responsibility on the person committing the damage.

Edward E. Wall: There have been thirty-two cases of damage done to fire hydrants in St. Louis by moving vehicles and cars during the past year. The total cost of repairing these 32 hydrants was \$1097.21. The Water Division has collected from the parties responsible for the damage the sum of \$542.62. Some of the bills still unpaid will be collected later on, but in a number of these cases no damage will be collected for the reason that the parties are in some cases unknown, in other cases are not financially responsible or are non-residents so that an attempt to get service on them and bring suit would cost a great deal more than the damage amounts to.

In three cases damage was done by wagon, in nineteen cases by automobile (passenger cars), in four cases by trucks, in one case by street car, in one case by switch engine and in four cases by freight cars.

The cost of repairs per case ranges from a minimum of \$3.95 to a maximum of \$97.50.

A number of cases occurred on account of machines or trucks skidding on wet streets. At least two cases were caused either by collisions of two machines or in the attempt to avoid collision.

In one case there was a collision between two automobiles at a street intersection in which one of the colliding machines was thrown violently against a machine standing at the curb, driving it against the fire hydrant. This brought up an interesting question as to who was responsible for the damage—the innocent by-stander, or the machine that collided into the standing vehicle, or the one that was the cause of the collision. The Water Division has not been able to decide this question, and the damage remains unpaid to this day.

In another case the owner of a truck, who was driving it himself, stopped his machine at the top of a grade and went into an adjoining store. Either his brake was not put on properly or it would not hold, and the truck started down hill. Hearing the noise, he rushed out but was unable to catch the machine, as it had made considerable headway before he appeared. It traveled about a block and ran into a fire hydrant, breaking it short off at the ground. The owner who, by the way was a native of sunny Italy, protested that it was not his fault that the machine ran away, brought his alderman and some other influential men to testify to his poverty and ask that he be excused from paying any damages on the ground that the whole occurrence was an act of Providence.

As the Water Division has more than 12,000 fire hydrants in service, thirty-two accidents in one year, more than half of which have been paid for, do not seem to constitute a very serious matter or one that would require any change in the design of the hydrant or the method of locating them just inside the curb.

Thirty years ago practically all the hydrants in St. Louis were of the under-ground type. These were abandoned for several reasons, among them being the impossibility of quickly locating the hydrant after a snow fall in the winter time. It used to be one of the emergency duties of the Street Service Section to get out after every snow storm, day or night, and clear off the covers of all under-ground hydrants. Another objection to the underground hydrant was the likelihood of the cover plate being knocked out of place, leaving a dangerous opening in the sidewalk or forming an obstruction over which pedestrians might stumble and fall. The city had numerous law suits over this before these under-ground hydrants were finally abandoned, especially in the business district.

They have been replaced by the single-nozzle self-draining post hydrant, which has given excellent satisfaction. Both the under-

ground fire hydrant and the old style of post hydrant in use in St. Louis require a box around them with a cast iron cover. This box is for the purpose of giving access to the joint between the fire hydrant and the gooseneck and also to allow for opening and closing the cock which drains the barrel of the plug. Every winter it is necessary to continuously inspect these hydrants to see that the drain cocks are open. The cost of the surrounding box with a cast iron cover runs from $12 to $15 per hydrant. The present design of hydrant requires no box or cover and costs no more than the old hydrant. During the extremely cold weather of 1917–18 not one of these self-draining hydrants was frozen.

C. W. Wiles: It has been the experience at Delaware, Ohio, that if a hydrant has its parts made on the interchangeable system it is more economical to replace parts that become broken than to weld the broken parts. If a hydrant becomes broken and it has no valve, the trouble is so great that the value of a valve is realized at once. Twenty-five years ago valves were rarely inserted on hydrant branches but today it is standard practice. Every new hydrant installed at Delaware has a valve, and valves are being placed on some of the old hydrant connections.[2]

W. S. Cramer: The speaker is from a small city of 40,000 population, where 12 hydrants were broken last year. All but one were repaired in a local machine shop by the oxyacetylene process at an average cost of $6.50; the exception was a case where the party breaking the hydrant had it repaired.

Moving hydrants is a subject provided for in the contract between the city and the water company, and all hydrants must be placed at locations selected by the chief of the Fire Department. No hydrant once set can be moved except by a city ordinance and at the expense of the city.

F. T. Kemble: It would be instructive to learn about any experience in setting hydrants back from the curb against a building. The only practical objections to this would be the possibility of

[2] At this point in the discussion President Henderson called for a vote, by show of hands, of members using valves on hydrant branches and those omitting them, and a very large proportion of those voting was shown to be using such valves.

damage in the cellar of the adjoining building in the event of any leakage and the difficulty of connecting up the fire engines. It would be necessary for them to use longer hose or else run up on the sidewalk. If a fire was so hot that it was impossible to handle the engine close to a building, it would hardly be possible to stay at the curb, but 15 feet further away. The hydrant close to the building would probably interfere with foot traffic less than out at the curb, and it would be safe from automobiles.

A number of hydrants are smashed every year at New Rochelle, N. Y., sometimes by trucks backing into them, but more often because of the careless driving of touring cars. In this section there are two roads, the Boston Post Road and the road along the Long Island Sound shore, on which automobiles are about as thick as they can be found anywhere. Hydrants are not apt to be troubled on these roads. It is generally on the semi-country roads, where often there may not be a curb, that the car skids or because of carelessness is run into a hydrant.

In nearly every instance where a hydrant has been smashed by an automobile, it has been possible to collect charges for the damage. Whether touring car or truck, it has generally been so damaged that it was possible to find out about it.

J. N. Chester: In small towns supplied by water works with which the speaker is familiar there are only one or two hydrants damaged annually. Usually there is a parking strip back of the curb and the hydrants are set back of this, so that unless a truck climbs the curb there is little chance of damage along streets laid out with such parking. When only a few hydrants are damaged annually it is probably less expensive to buy repair parts than to maintain a welding outfit to repair the broken parts. Such a welding outfit may well be advantageous in a large water works where it can be kept fairly busy, just as a large steel mill finds it advantageous to maintain a machine shop, but a small water works will probably not find any financial advantage in providing facilities for unusual repairs requiring skilled men to handle them properly.

Seth M. VanLoan: Approximately three hundred fire hydrants were broken by automobile trucks in Philadelphia in 1918, and the average rate of one a day is continuing through 1919. The congested central traffic zone is practically free from accidents of this

nature. The bulk of the trouble occurs on main streets outside of the central district, probably because of the tendency on the part of automobile trucks to increase speed where traffic is lighter or where wider streets incite to such higher speeds.

The majority of the Philadelphia hydrants are located at street intersections, placed 12 inches back from the curb on the house line. A few are placed in the center of blocks and the proportion of these which have been broken is nearly as high as those placed at intersections.

A number of hydrants have been broken on comparatively narrow double car-track streets paved with granite block. This is caused by the fact that trucks ordinarily ride the rails and in turning out from the rails the rear of the truck swings to the curb line and remains in that position for several feet before reaching alignment. The overhanging truck body is thus brought in position to interfere with the fire hydrant. Other accidents occur in the delivery of goods where trucks back up to the curb, in which cases also the overhanging truck body sometimes comes into collision with the fire hydrant. To this is attributable the majority of accidents occurring to fire hydrants placed in the middle of blocks.

Philadelphia uses the compression type of hydrant valve and has consequently experienced a minimum of trouble from washouts or loss of water because of accidents.

Various remedies have been suggested. If hydrants could be placed so as to give 24 inches clear space from the curb to the face of the hydrant, the number of accidents would be greatly reduced. A somewhat similar remedy would be to place the hydrants at the building line. Both of these remedies are objectionable in Philadelphia because of narrow sidewalks in many parts of the city.

Another suggested remedy which has received some consideration in Philadelphia is a sub-surface hydrant protected by a hinged cover arranged to be opened by a post attached to the cover at the opposite end from the hinge. This post would serve to readily indicate the location of the hydrant and would furnish sufficient leverage to open the cover even when it is more or less obstructed by ice or snow.

THE ORGANIZATION OF AN EMERGENCY GANG, PHILADELPHIA BUREAU OF WATER[1]

By Seth M. Van Loan[2]

The Distribution Division of the Philadelphia Bureau of Water consists of seven districts with offices in various sections of the city. Each office is in charge of a district engineer who is responsible to the general superintendent, whose office is in the city hall. The districts are divided geographically and with the idea of having either a large territory or a small and important business area where complaints demand quick action. The distribution system consists of about 1850 miles of water pipe, about 18,000 fire hydrants and 36,000 valves.

The organization of a special emergency crew has been given considerable thought and is being rapidly developed. The most important point in the organization of any emergency organization is to keep all valves controlling a shut-off in first-class condition.

The emergency crew will consist of three shifts of men, working on an eight-hour basis. The duty of the day shift will be to operate valves for the purpose of inspection. It is expected that the day crew will operate all large valves at least twice a year. If valves are kept in good condition the emergency organization will be a success.

Each detail will consist of an engineer in charge and three men, who will be able to make any important shut-off in any section of the city under the direction of the engineer. The duty of the engineer will be to make a study of the distribution system so he will be able to make any shift in the distribution system required by a break in the mains or a break at the pumping stations.

The detail gang will have an automobile equipped with a valve-operating device, so that all valves may be shut off quickly. The usual assortment of street keys will be placed on the machine, in case the operating device fails to work.

[1] Discussion of this paper is requested and should be sent to the Editor.

[2] General Superintendent, Bureau of Water, Philadelphia.

Plans will be prepared showing the actual location of valves pertaining to shut-off, and instructions will be given on each shut-off sheet to enable the gang to make any necessary shift in distribution.

Each man on a shift should be able to operate the automobile and the valve-operating device, so that a failure to report by any one man will not prevent the work of the organization. For the ordinary complaints of leaks in cellars it is expected that two shifts of three men each on motor cycles will be able to handle these to the satisfaction of the public.

The telephone service is now of great assistance in case of trouble and will be still more important when the emergency detail organization is developed. This service is expected not only to handle the original complaint but also to take personal charge of notifying the chiefs of all divisions whom the break affects and keep them in touch with all operations of valves. It must answer all questions concerning short supplies caused by a break and notify the Police Department and ask its coöperation in locating workmen to make necessary repairs.

Of course, it is understood that only large organizations can afford the expense involved, but it is believed that the first obligation is to give to the public the service that it demands and give it as economically as possible.

EXPERIENCES WITH FROZEN SERVICES, MAINS AND METERS DURING THE WINTER OF 1917-18, ROCHESTER, N. Y.[1]

By Beekman C. Little[2]

There used to be an annual joke, appearing about the middle of January when the weather was the coldest, to the effect that now the poet was deep in his work of writing up the beauties of spring. The author finds the converse of this is just as big a joke, that is, in this beautiful month of May, to write about the horrors water works men went through during the winter of 1917–1918. Although warned by the censor against the accumulation of a lot of statistics, it will be necessary to use some figures in order to bring out more clearly the conditions with which Rochester had to cope.

The city of Rochester has a population of approximately 255,000 persons who use the city water, and on January 1, 1918, it had over 49,000 meters. Being over 99 per cent metered this means in round numbers 50,000 active water services. While the water department was in the thick of the battle against the calamity of frozen pipes, it seemed at times as if the whole 50,000 wanted thawing at once, but now that there has been time to go over the figures, it has been found that during the entire winter, less than 3 per cent of the meters were damaged by frost, and less than 1 per cent of the services were frozen or, in other words there were some 1,400 meters to repair and some 375 services to thaw. The last frozen service was thawed out on April 30, when frost was still in the ground.

It is understood that in speaking of frozen services reference is made only to that portion of the pipes outside of the building or residence. There were naturally innumerable cases where plumbers were called in to thaw frozen pipes in cellars, basements, garages, barns, etc., but these are not considered in this paper. All told there were about three times as many frozen meters as in an ordinary

[1] Read at the St. Louis Convention, May, 1918, and referred to the Committee on Cold Weather Troubles. Discussion is desired and should be sent to the Editor.

[2] Superintendent Water Works, Rochester, N. Y.

year and many times the usual number of frozen services. In the hard winter of 1911–12 there was the nearest approach to the recent difficulty, there being about 200 frozen services at that time.

The heaviest day's business this winter (1917–1918) came on February 7, when 55 services were reported frozen. This big day followed very closely the coldest day of the winter, which occurred on February 5, when the thermometer reached $-11°$.

The services, and very generally the mains, in Rochester, are laid at a depth of 4½ feet, that is, 4½ feet over the top of the pipe, which is evidently not deep enough in a winter as severe as this one just passed, for in many places the frost was found to have penetrated 5 feet or even deeper. However, as such severe continued cold weather apparently occurs at very long intervals, there has been no disposition on the part of those in charge of the waterworks management to increase the depth at which the water pipes should be laid.

The great majority of the frozen services in Rochester were thawed by the local Railway and Light Company, which charged for each service separately, based on the time and labor involved. An arrangement was made whereby the house owner signed an application in the water office, agreeing to pay the expense of thawing out his frozen service. The Railway and Light Company was notified of the applications as rapidly as possible and in the order in which they were received and they were taken care of in this same order, although preference was given in cases where illness prevailed. After doing the work, the light company would send a bill to the Water Department for work, say, in thawing John Smith's service at 100 Jones Street on February 1, \$5.40. The Water Department would then send out this bill and collect the amount from John Smith, the property owner who had signed the original application.

In some cases, where obviously the freezing had taken place in the street, that is, between the curb and the main, the owner was not obliged to pay, as the Rochester water works rules state that the Water Bureau shall maintain the service from the main up to and including the curb-cock.

The average charge made by the Railway and Light Company was \$5.40, the smallest charge being \$2.25 and the highest \$39.00, except in one case of a long line of wrought iron pipe laid for a contractor on Barge Canal work. There was no electric current near

this pipe and quite a long line of wire had to be laid; in this case the charge was \$139.00.

From one to eight gangs at a time were used for thawing, depending on the demands for their services, and even eight gangs were not enough some days. An outfit consisted of three men from the Lighting Company with their wire and transformer, which weighed perhaps 700 pounds, and two men (one plumber and one chauffeur) from the Water Bureau, and a water works light automobile truck, on which the wire, transformer and men were carried. Although not charged against the property owner, the Water Bureau's expense connected with the thawing averaged \$2.10 per service, which added to the charge of the Railway and Light Company, made the entire expense \$7.50 per service.

Both direct and alternating current were used at different times in certain localities, as the old Edison lighting system is used to a certain extent in the central part of the city, and when this was available direct current could be used. In the direct-current system, after the connection to the wires of the lighting system were made, just one connection was made to the water service inside the basement or cellar. When alternating current was used, an additional connection would be made, generally to the nearest hydrant or occasionally to a curb-cock outside the premises. The actual thawing took less than a minute in some cases and in the extreme case mentioned before, when a charge of \$139.00 was made, 2½ hours expired after the current was turned on before the water started.

About 25 of the frozen services were thawed by the Water Bureau's repair force, by means of a steam jet. The men used a small gasoline boiler of the porcupine type, which was carried around on an automobile truck. This boiler weighs perhaps 75 pounds and was light enough to be carried into a cellar. When the water pipe was disconnected at the meter, a jet of steam at a pressure of about 70 pounds would be forced into the pipe toward the street main through a ¼-inch flexible block-tin pipe. The time required for thawing would depend, of course, on the length of pipe frozen.

In thawing out such hydrants as might be found frozen, a somewhat larger kerosine boiler (called the Acme Safety, a sectional boiler having five sections or drums) was used, and a larger jet of steam was applied through a rubber hose. In case the hydrant *branch* was frozen, the hydrant would be removed and this same large steam jet applied directly to the branch.

Very few hydrants were frozen as men were kept constantly at work inspecting them. Although there were no large fires, there was not one case, at any fire which did occur, of a hydrant being found inoperative. In perhaps 7 or 8 cases where the men found the hydrant branch itself freezing or frozen up, the branch was thawed and then a bleeder was attached to one nozzle of the hydrant and the water allowed to run constantly into the nearest surface sewer lateral.

Only one main was frozen. This was a 6-inch line about 400 feet long, with no services from it and no connections, and consequently no circulation. It was thawed by electricity without particular difficulty.

The Water Bureau discovered and thawed out seven 6-inch services feeding automatic sprinkler systems, and the condition of these led to a rather disquieting thought, that possibly there were a number of these sprinkling systems, or exclusively fire line services, which might be frozen or partly frozen and this dangerous condition not be discovered until the fire system was needed for duty, when of course it would fail. A regular water service, being used almost constantly, at least during business hours, indicates at once by its failure to furnish water that something is wrong, but with the fire services the conditions are different and such a service might remain frozen quite a time before this was discovered. Even opening a bleeder to see if the water would run on such a system would not insure its perfect condition.

In one case it was necessary to take out a 6-inch Detector meter which had cracked from the water freezing and expanding; the water was spurting out all over the basement floor. The main was shut off at the operating gate in the street and when the meter was taken out, it was found that although the service was a 6-inch cast iron pipe, its capacity had been reduced to that of a 2-inch or less by the ice that had formed inside. The ice had evidently begun to form at the circumference and had frozen in toward the center. Another year, if one occurs, which Heaven forbid, when the frost penetrates as deep as it did this past winter, this danger to fire services should be kept in mind by the water works superintendent. A small stream of water left running continually, if started before any ice had formed, would possibly keep the pipe entirely clear of any ice formation.

This letting water run to prevent freezing is of course theoretically a very wrong thing to do. Our mains should be laid deep enough, our pipes and plumbing so planned, and our cellars and basements kept warm enough, to make freezing impossible. This winter, however, was exceptional not alone in its severity but also because of the fact that coal was scarce and very high in price. This difficulty in getting coal caused many people to give up partially or even entirely heating their cellars. This, together with a temperature, as recorded by the Weather Bureau for January, averaging for each day, over 9° colder than normal, and fixing the month as the coldest in the forty-year history of the Weather Bureau, made a combination which upset many rules not made to meet such extraordinary conditions. Consequently, for the first time in Rochester, but only in cases where a service had once frozen, the owner was told to let the water run constantly, and in many cases the Water Bureau cut a notch in a washer in some faucet to be sure that the water would not be shut off.

In case a meter was frozen, the Water Bureau removed the meter and inserted a filling-in section of pipe and did not replace the meter until all danger of freezing was over. In these cases, as long as there was no meter to record the waste of water, the occupant hardly had to be told that he could let the water run. The Bureau averaged the bills in each case on the basis of former consumption. The fact that actually only a small percentage of the entire number of meters and services was affected, made only a slight increase over the normal consumption. Had the severe weather continued much longer, however (for we were beginning to feel a little panicky) a general notice would have been published in the papers requesting *all* users to let the water run continually and this of course would have sent our consumption curve away up.

The normal daily per capita consumption is close to 100 gallons and on the coldest day, which coincided with the heaviest consumption, only 125 gallons per capita was registered. Through the entire month of February, the consumption averaged only a little over 104 gallons per capita per day.

There is not a great deal more of special interest to tell. The Water Bureau repaired and reset practically all of the 1400 frozen meters. Beginning to reset about the middle of March, 43 meters were replaced daily for thirty-one days. On one day 90 meters were replaced, using six light automobiles, with two men to each car.

This record was really broken, however, on one day when with four rigs and eight men 83 meters were replaced. In addition to replacing all these meters during the month, this same force of men removed in the same period, an average of 17 meters a day. The average labor cost of removing and resetting a meter was[3] $1.14. The average labor cost of repairing was $1.34 per meter and the cost of materials for repairing,[4] 71 cents per meter. These figures give an average cost for taking out a meter, repairing it and setting it back, of $3.19.

It was not possible at all times, of course, to keep up with the complaints, but by working Sundays and even some nights, the men prevented the work piling up too far ahead of them, and a tactful interview by a reporter now and then, in which the Bureau explained to the public its experiences and difficulties, helped very materially to lighten the worries.

[3] 1429 removed, 1503 repaired, or an average of 1466, cost $1,674.04 in February, March and up to April 15.

[4] 1187 meters repaired, labor equaled $1,589.71, repair materials for 1551 meters cost $1,101.58.

A NEW MAXIMUM IN WATER CONSUMPTION AND FROZEN SERVICE LINES[1]

By F. E. Kingsbury[2]

The extreme severity of the past (1917–1918) winter developed, to a remarkable degree, two phases affecting the water distribution in the City of St. Louis; that is, the abnormal consumption of water during the period of low temperature, and the freezing of service lines that were supposed to be of sufficient depth to be out of danger from that source. Extremely cold weather is seldom known in this locality, but last winter the unusual conditions prevailing throughout the country were experienced to a great extent in St. Louis and vicinity.

During normal weather in 1917, the average daily consumption of water in St. Louis was 92,000,000 gallons. In hot and dry weather, when 570 miles of streets are sprinkled five and often six times a day, 15,000,000 gallons or more are used for this purpose. Add to this the amount used for street flushing at night and the innumerable lawns that are sprinkled both day and night, and it is possible to account for a maximum summer consumption of water on June 26 of 133,900,000 gallons.

One might naturally suppose that a protracted hot, dry summer would tax the Water Department more than at any other time. But such was not the case in St. Louis during 1917. In fact, the greatest consumption of water in the history of the city for any twenty-four hour period was experienced on the coldest day of the season. On this day, January 12, 1918, the United States Government official thermometer recorded a minimum temperature of $-17°$ and the St. Louis Water Department showed a consumption of 156,500,000 gallons of water, 64,500,000 gallons above the normal

[1] Read before the St. Louis convention in May, 1918, and referred to Committee on Cold Weather Troubles. Discussion is requested and should be sent to the Editor.

[2] Assistant Engineer, Distribution Section, Division of Water, St. Louis, Mo.

amount used. In line with the above, it will be of interest to quote from a paper read by Edward E. Wall, Water Commissioner, before the Engineers' Club of St. Louis, March 13, 1918:

From December 28th to February 8th inclusive, a period of 43 days, an average of 126,400,000 gallons was recorded. It must be remembered that no water could be used during this time for street sprinkling or washing, so that the normal use of water would have been no more than during moderately cold weather in November or March, when the consumption averaged about 92,000,000 gallons. The difference between 92,000,000 and 126,400,000 would represent what may be called the super-waste of water during a period of 43 days, amounting to $60,000 at the rate of $40 per million gallons.

The use of 92,000,000 gallons daily under moderate weather conditions is about 120 gallons per capita, meaning that at least 10,000,000 gallons are normally wasted during the periods of most favorable weather, and super-waste occurs at all other times. The coal burned per million gallons of water pumped, by actual weights taken in the boiler rooms, averaged 3800 pounds. This means that over 65 tons of coal were consumed each day for 43 days in pumping water that was allowed to run to waste into drains and sewers. This 2800 tons of coal was consumed at a time when the United States Fuel Administrator was urging economy and restricting coal deliveries to the bare necessities of preferred classes of consumers.

As long as the cold weather lasted, a great amount of water was used above the normal consumption of 92,000,000 gallons, and it is safe to say that it was wasted by allowing faucets throughout the city to run night and day in order to avoid the freezing of fixtures which have actually been installed frost-proof, for the city ordinances require that every residence must have a cut-off and drain inside the building where the service line enters. Obviously, this need only be turned off during the nights of severe cold, as there is always sufficient water being used during the day to prevent freezing.

Investigation showed that in some residences all faucets on the premises were left wide open. This was, without question, an extravagant waste, yet a large number of citizens exercised some judgment, and in districts where frozen pipes were anticipated, moderation was used in the amount of water allowed to flow.

A short time ago, one of the St. Louis daily papers published an open letter that contained a frank admission of the above facts and also stated the remedy: He says:

Last winter a valve in my house leaked, the water dripped continually; I informed the landlord, but, because it cost him no more to let it leak, he neglected to make the necessary repairs, and I, being no better than the

average, because it cost me no more, did not insist on it. Consequently the water dripped for months. Pure waste, which would have been quickly stopped had either landlord or I been paying for water by meter.

In severe weather the proper way to keep the pipes from freezing is to turn off the water from the house and drain the pipes each night. This is a bother and takes time. It is easier to let the water run all night, and it doesn't cost any more. I do it the easy way, so do you; if we had meters we wouldn't and we would save water.

No one wants to skimp on water; let us use all we need, but why waste it? (Signed) Charles Baker.

There are many others of the Charles Baker type who waste water because they pay for it on the flat rate. They do not seem to realize that with economy water would cost less on a meter rate. But the sentiment at large is against meters at the present time.

The City of St. Louis was rather fortunate in not having any street mains frozen. However, there were quite a number of private services from the street main into residences that were frozen to a greater or less extent. Most of the frozen service pipes were in sections of the city where street grades had been lowered after the water lines had previously been placed in accordance with the usual requirements.

All services are the property of the consumer and not of the Water Division, so that the responsibility for their maintenance and repair does not rest with the city. If the Water Division owned these services and was required to keep them in working order, it might be an economical proposition to allow a limited waste of water to prevent freezing of services, rather than to assume the expense of repairing numerous burst pipes.

The Water Department has supervision over the laying of service lines that are more than 2 inches in diameter. All services over 2 inches in diameter are of cast iron pipe and are installed by the Water Division from the city main to the building line at the expense of the owner. There were no reported cases where cast iron services, in use, were frozen.

Most of the frozen lines were the usual $\frac{5}{8}$-inch or $\frac{3}{4}$-inch lead services to private property. The thawing of them was handled by local plumbers, who rarely have to cope with a situation of the kind, and consequently the emergency was met in a great variety of ways that were more or less crude, but nevertheless solved the problem. They are recorded as a matter of history only, and not as examples to be followed, except in cases where better methods are out of the question.

Inquiry at some of the largest plumbing supply houses of St. Louis revealed the fact that they do not make or handle any device suitable for thawing service lines. One of the large supply houses reported that years ago they offered for sale an electrical thawing apparatus, which proved unsatisfactory, and the sale was discontinued.

Some plumbers advised their patrons to let the situation take care of itself, trusting that, in the course of a short time, the earth would thaw again. Others proceeded with the expensive method of digging the frozen ground, thawing the service pipe and then lowering it to a sufficient depth.

A number of the local plumbers, however, have constructed a portable steamer to which is attached a quarter-inch rubber tubing. This is inserted into the service pipe and pushed through as fast as the thawing will permit. This method required from three to eight hours, depending on conditions, the cost ranging from $10 to $15. It is stated that no service thawed in such a manner was ever frozen a second time.

The Water Division has a record of one case where a plumber undertook to thaw a frozen service line and proceeded in the old way to dig the frozen ground. Then the service pipe was thawed and lowered, the frozen earth replaced as well as possible, sand being used to fill the voids, which was necessary to make a good foundation for re-surfacing the street. The statement rendered for this job included: 37 hours for plumber's time at $1.25 per hour, 69 hours for plumber's helper at 75 cents per hour, and $9 for repaving the street and city inspection. The total amount of the bill was $141.15.

From the best information obtainable throughout the country at large, the electrical outfit is by far the most satisfactory method in cost, time, labor and every other way, where a great number of services or even street mains are to be thawed. Especially should an apparatus of this kind be ready for use in localities where freezing is an annual occurrence, and where the water department is so unfortunate as to own the service lines from street mains to the property. But in moderate climates and where frozen services are an exception rather than the rule, the small portable steam outfit with rubber tubing is sufficient for the emergency, when the thawing is done by local plumbers.

A REMARKABLE PUMPING PERFORMANCE AT THE NORTHEAST PUMPING STATION, MINNEAPOLIS[1]

By F. W. Cappelen[2]

The object in presenting this paper is to show the great advance that has been made in the art of designing and constructing electrically driven centrifugal pumping machinery in the last few years. Extracts from the specifications upon which the city of Minneapolis received bids are presented and from the contract and proposal from the pump manufacturer, as well as his exceptions to the city's specifications, for the benefit of engineers who may have similar work under consideration.

The efficiency test is presented, as well as actual operation data for a period of the first three months after the test run, as well as data for the first nine months of operation, showing the maintenance of the high efficiency guaranteed by the pump manufacturer.

The installation, as well as the test, was in charge of J. A. Jensen, supervisor of the Minneapolis Water Works, and E. C. York, chief engineer of the Minneapolis pumping stations. The test, as far as the city is concerned, was in full charge of F. W. Springer, professor of electrical engineering at the University of Minnesota, and William Salt was the representative of the pump manufacturer.

Extracts from the Detailed Specifications for Electric Motor Driven Centrifugal Pump

The City of Minneapolis, Minnesota, proposes to purchase one 30,000,000 gallon electric-motor-driven centrifugal pump, to be placed in the Northeast Pumping Station. The pump must deliver 30,000,000 gallons of water in 24 hours against an average dynamic head of 250 feet, in which the suction lift, not to exceed 16 feet, is included.

These specifications are intended to include a complete equipment, erected on foundation furnished by the City of Minneapolis, ready for suction and discharge pipe connections furnished by the City of Minneapolis, and ready for

[1] Read before the Minnesota Section, May 3, 1919. Discussion of this paper is invited and should be sent to the Editor.

[2] City engineer, Minneapolis, Minn.

electrical energy. The City of Minneapolis will make the connections to the suction and discharge piping, and the pump manufacturer will be expected to have the pump equipment ready with suction and discharge flanges drilled for standard connections.

It is the present intention of the City of Minneapolis to purchase the pump prior to November 15, 1916. The pump is to be delivered, erected and connected, in a complete manner, ready for tests within six months thereafter, or on May 15, 1917. A forfeit of $100 per day will be made and deducted from the contract price, as liquidated damages, for each day, after the above specified time of completion expires. The city reserves the right to operate said pump for sixty days, pending the final acceptance and testing of the pump by the city.

The word "Pump" refers to and means the complete pumping unit with cast-iron base, rotor, motor, stator, controller, switchboard, and all accessories necessary for the ordinary operation of the pump. The word "Efficiency" refers to and means the combined or total efficiency of the pump with its electric motor. The words "Dynamic Head" refers to and means the difference in levels, in feet, between the surface of the water in the city water settling reservoir, and the surface of the water in the river supply well near the pump suction main, plus the friction head in feet. The term "Manufacturer" or "Contractor" shall be deemed to mean the party whose bid has been accepted for the installation of the pumping unit.

The pump will take its water from the Mississippi River and deliver the water through 50-inch and 54-inch pipe lines to the settling reservoir, at the Filtration Plant, under average dynamic head of 250 feet.

Motor. The manufacturer of the pump equipment is to furnish an electric motor for the driving of the pump. The motor is to be of the horizontal, direct-connected, three phase, 60-cycle, 2200-volt, slip-ring, induction type. The motor shall be capable of starting the pump from rest when the pump is primed and when the check or gate valve in the discharge is closed, and bring the pump to full speed without drawing more than 150 per cent of full-load current from the source of supply. A modern motor is required, and one having an efficiency on full load of at least 94 per cent. The short-circuited rotor losses are to be reduced to a minimum, during normal running. Pedestal type ring-oiling bearings are required, that can be removed by removing bearing caps.

(A) The slip of the motor from synchronous speed on full pump load, namely; at the rate of 30,000,000 gallons per day against 250 feet dynamic head, shall not exceed 1.7 per cent of synchronous speed.

(B) The rise in temperature of any part of the motor after 24-hours run with full pump load, shall not exceed 40° Cent. above surrounding temperature.

(C) American Institute rules shall govern for definitions and for motor tests.

Switchboard. One switchboard panel, to support meters and controller, is to be erected and connected in the pumping station. This panel is to be made of either two or three slabs of blue Vermont marble on which the following are to be mounted.

1 Oil switch, for a 2200-volt, three-phase, 2000-kilovolt-ampere circuit, with overload and no-voltage release, and with interlocks to the controller switches.

3 Ammeters; 1 voltmeter; 1 cyclemeter; 1 power-factor meter.

1 Curve-drawing wattmeter, with 1500-kilovolt scale, and record sheets for one year of continued use.

1 Recording wattmeter to integrate the kilowatt-hours used for pumping service.

1 Westinghouse controller, or equal, with rheostats for starting the motor.

Necessary transformers; two lamp fixtures; wiring; card racks; panel supports; rheostat supports, etc., to make a complete outfit.

Wiring is to be furnished and connected between the switchboard, controller, rheostats and the motor, and this wiring is to be paper insulated, lead covered, pot-leaded, laid in fibre conduit, and the insulation is to conform to the ordinances regulating electrical work in the City of Minneapolis. The meters are to be carefully calibrated and sealed and must be accompanied with a certified calibration curve or table.

Pump Rotor. The rotor for the pump is to consist of a forged steel shaft on which a two-stage bronze impeller is to be mounted. That part of the shaft which is exposed to rusting by water, including that part running through the stuffing boxes, is to be protected by a bronze sleeve. The impeller itself is to have balancing chambers, and at the end of the shaft a marine-type thrust bearing is to be provided. The impeller is to work in perfect rotative balance.

The bearings are to be babbitt-lined, and of the double ring-oiling pedestal type, that can be removed without disturbing any part of the pump except the bearing caps.

The shaft coupling between the motor and the pump rotor is to be of the flexible type.

The stuffing boxes are to be of ample length, packed with non-rusting, high-pressure, hydraulic packing. The glands are to be provided with water seal and necessary connections therefor. The necks and glands are to be lined with brass.

One extra set of impellers and also a complete set of division rings are to be furnished with the pump.

Pump stator. The stator of the pump shall be a rigid casting properly designed to hold the shaft and to guide the water from the impellers. A casting which is made in two parts, rather than four or more parts, and a casting which can be opened without dismantling the suction and discharge pipe connections, is preferred. The inside of the stator is to be protected with an anti-rust metallic paint.

Between the rotor and the stator, the necessary packing rings of brass are to be provided, to seal the water pressure from the impeller.

The pump stator and the motor are to have one cast-iron integral base.

Priming and drain connections are to be arranged and fitted between the pump stator and the source of supply and discharge. An ejector or vacuum equipment will be used and furnished by the City of Minneapolis.

The flange connections at the pump, for the discharge and suction piping, are to be drilled by the manufacturer.

Guarantees. A diagram or table is to be furnished by the pump manufacturer, at the time of making the proposal to the City of Minneapolis, showing the guaranteed capacity of the pump in gallons per day, and the guaranteed efficiency of the pump when working at rated speed, with dynamic heads varying from 240 to 275 feet, with a maximum efficiency when head is 250 feet. The efficiency should be fairly uniform over the full range of dynamic head.

Tests. The said pump is to be erected and connected complete by the pump manufacturer or contractor, after which, the service and the efficiency of the pump are to be not only tested but passed upon by the representative of the contractor or manufacturer, and the representative of the City of Minneapolis, appointed by the Water Works Committee of the City Council, for the purpose of determining whether or not the guarantees for the capacity and efficiency as herein specified, are fulfilled. In case the representative of the company and the representative of the city cannot agree, then, in that case, said representatives shall appoint a third man, who shall be a competent engineer; and the decision of two of the three judges thus appointed shall be final and binding both upon the city and the manufacturer or contractor.

Should the representatives of the city and the manufacturer or contractor be unable to agree, then, in that case, a Judge of the District Court of Hennepin County, shall appoint a third man, who shall be a competent engineer, to act as arbiter between the manufacturer and the city, and under the same conditions as above set forth. The appointment by a judge of the District Court, shall only be made upon 10 day's notice by either party to the other, or by mutual agreement.

For the purpose of testing the pump, a Venturi meter, manufactured by the Builders Iron Foundry, shall be used and accepted, both by the city and the manufacturer, as the measuring device for the purpose of ascertaining the amount of water pumped, that is, for the purpose of determining the efficiency and service of the pump.

The accuracy of this Venturi meter shall be deemed to be correct; unless the pump manufacturer is able to establish, by tests or other satisfactory evidence, that the meter, either in whole or in part, is inaccurate, and the Venturi Meter in this proposal is deemed to be both the tube, so called, and the recording device. Provided, the company furnishing the meter to the city shall guaranty the Venturi meter, including the tube and the recording device, to be accurate within one and one-half per cent. That is to say, the service and delivery of the pump are to be accepted and tested upon the basis of the meter, subject to provisions hereinbefore set forth.

All other meters used in testing shall be checked by and at the expense of the City of Minneapolis, and certificates therefor shall be acknowledged.

Efficiency. In case the efficiency of the pump shall be determined to have exceeded 76 per cent, the manufacturer furnishing said pump shall be entitled to a bonus of $500 for each one per cent or fraction thereof, over and above the contract price. In case the efficiency of the pump shall be found to be less than 76 per cent, then, in that case, the manufacturer or contractor furnishing said pump, shall forfeit to the City of Minneapolis, to be deducted from the contract price, $500 for each one per cent or fraction thereof. Provided, how-

ever, that the total amount of bonus shall not exceed $2400. However, the pump shall not be accepted if it falls below 72 per cent.

Payments. The manufacturer shall be entitled to full compensation for the pump furnished, at once, after the pump has been tested and accepted by the Water Committee of the City Council of the City of Minneapolis.

Reservations. The right is reserved to reject any or all proposals, or any part of any proposal, and to make minor modifications in the specifications prior to the acceptance of a proposal.

Extracts from Contract with the Minneapolis Electric Equipment Company

The party of the first part hereby agrees to manufacture, furnish, deliver and install for said second party at the Northeast Pumping Station, in the city of Minneapolis, Minn., on foundations to be furnished by said second party, two 24-inch DeLaval single-stage pumps with equipments, connected in tandem and operating in series at a speed of approximately 590 R.P.M., said pumps to be designed to deliver 30,000,000 gallons for 24 hours, against a total head of 250 feet, including 16 feet suction lift, direct-connected to an 1800-H.P. 600-R.P.M. form "P," 2200-V., General Electric motor and General Electric switchboard and instruments throughout and General Electric drum controller, and furnish all the material and do and perform all the work and labor necessary therefor, all in strict conformity with the plans and specifications for said pumps prepared by said second party as modified by the proposal and specifications for said pumps submitted by said first party and the addenda attached to said specifications, ... and to complete the installation of said pumps and equipments by the 1st day of March, A.D. 1918, all for the sum and price of $26,000, ...

Said first party further agrees and guarantees that the pumps and equipments furnished by said first party under this contract shall and will deliver not less than the quantities given in the following table, when 3-phase, 60-cycle, 2200 volt current is furnished at the terminals of the motor, the heads as given being understood to be total heads developed by the pumps, measured by means of calibrated gauges located at the suction and discharge nozzle of the pumps, and corrected for difference in elevation, if any. The efficiencies guaranteed are based on operating the pump at total head as specified and at a discharge rate not less than the quantities stipulated, and it is understood that the suction lift shall not exceed 16 feet. Said table above mentioned is as follows:

Total head in feet	*Million gallons per day*	*Combined efficiency of pump and motor*
275.0	24.0	74.3
262.5	27.4	75.9
250.0	30.0	76.0
237.5	31.8	75.2

Extracts from Letter Accompanying Proposal of Minneapolis Electric Equipment Company

The centrifugal pumps offered to the City of Minneapolis will be manufactured by the DeLaval Steam Turbine Company, Trenton, N. J., a concern devoted exclusively to the manufacture of rotating apparatus, including centrifugal pumps, steam turbines, reduction gears and blowers. All renewable parts are made to limit gauges so that replacement can be made in the field by comparatively inexperienced men and without the necessity of doing any machine work. This applies particularly to such items as impellers, impeller wearing rings, case protecting rings, shaft sleeves, bearings, glands, etc.

The proposal is not based on the detailed specifications of the City of Minneapolis. The proposals which we are making are subject to prompt acceptance by the City and prices named are subject to change without notice on and after November 15th, 1916.

We will guarantee to have the equipment covered by the attached proposals delivered, erected and connected in a complete manner, ready for attachment of suction and discharge piping, and ready for electrical connections within fifteen months from date of receipt of signed copy of proposal. The specified date for completion of the work is subject to any delays on your part in supplying us with necessary data or any changes in same, as well as to delays due to fires, floods, strikes, accidents or other causes beyond our reasonable control, and subject to such delays we are willing to agree to forfeit $100.00 per day for each day after the above specified time of completion expires, but in no case shall we be liable for consequential damages.

The word "Efficiency" is to mean the combined efficiency of the pump with its electrical motor, based on electrical imput being measured at motor terminals, total head being determined by calibrated gauges located at the suction and discharge nozzles of the pump and corrected for difference in elevation, if any, and rate of discharge being determined by means of a venturi meter, which the City guarantees to be correct within 1½ per cent.

Your specifications call for 2000-KVA circuit breaker. This would necessitate using an 800 ampere circuit breaker. We have disregarded this, and are furnishing a 500 ampere oil circuit breaker.

The rotating element of the pump will consist of two forged steel shafts on each of which will be mounted a single stage bronze impeller. The shafts will be protected from wear and contact with water by removable protecting sleeves, extending from the impeller to the outer ends of the stuffing boxes, completely covering the shaft and providing a bearing surface for the packing.

Each impeller will be of the double suction type, completely balanced within itself.

Each shaft will have a marine type of thrust bearing at one end. Each shaft will be carried in two bearings with ring oilers. The bearing shells will be held in bearing brackets bolted to the pump casing. The bearing shells will be babbitt lined and may be removed without disturbing any part of the pump except the bearing caps. Necessary couplings will be furnished and they will be of the flexible type.

The stuffing boxes will be arranged for soft packing and are provided with water seals and all necessary drip boxes and drainage openings.

The glands are of the split type and can be removed without disturbing other parts, thus facilitating the examination or replacement of the packing. The glands will be of solid brass; the stuffing boxes will not be lined with brass, as this is unnecessary.

The impellers will be of bronze; the impeller protecting rings will be of bronze, and the case protecting rings will be of brass.

The stationary portion of the centrifugal pumps will consist of two pump casings, connected together by suitable series piping, which is furnished under this contract. Each pump casing will consist of two complete parts, separated horizontally in the plane of the center line of the shaft by a flat joint scraped to fit and maintained air and water tight by a thin paper gasket. The lower half of the casing will contain both suction and discharge openings so that the pumps can be opened without disturbing suction and discharge piping connections.

We cannot agree to furnish detailed drawings of all parts of the equipment, but can probably furnish drawings of such parts of the machines which can be made by the City or for the City by the ordinary machine shop. Pump case and pump impeller drawings will not be furnished under any consideration.

It is intended that the machinery is to be free from latent defects in material and workmanship, and should any part of it be found, within one year from date of arrival f.o.b. cars Minneapolis, to have been defective at the time furnished, we will repair said part f.o.b. Manufacturer's Works, or will furnish without charge f.o.b. Manufacturer's Works, similar part to replace it, provided the original part is returned to Manufacturer's Works, freight prepaid, and Manufacturer's inspection establishes the claim. We will make no allowance for repairs or alterations unless same are made with our written consent and approval.

Payment for the equipment shall be made as follows:

Twenty-five per cent cash on shipment of apparatus, as evidenced by presentation of bill of lading.

Twenty-five per cent cash on completion of erection ready for piping and electrical connections.

Fifty per cent cash sixty (60) days after second payment becomes due, provided the equipment has met all the conditions and stipulations of this proposition.

It is mutually agreed that if the erection of the equipment is delayed by the City, the second payment is due thirty days after arrival of the equipment f.o.b. cars Minneapolis, and final payment is to be made in not to exceed 180 days after arrival of apparatus f.o.b. cars Minneapolis. If the starting and testing of the equipment is delayed for any reason beyond our control, final payment is to be made in not to exceed sixty days after completion of erection ready for piping and electrical connections.

EXTRACTS FROM SPECIFICATIONS PREPARED BY GENERAL ELECTRIC COMPANY

Pump motors. Power factor and efficiency guarantees will be in accordance with detailed specification sheet which is included. The motor will operate for 24 hours at normal rated output with temperature rise in any part not exceeding 40° Cent.; and for 2 hours at 25 per cent overload without injury. The overload heat run will immediately follow the normal load heat run.

SPECIFICATION SHEET FOR INDUCTION MOTORS

CLASSIFICATION

	Type	Poles	H. P.	Sny. speed R. P. M.	No. of Volts	No. of Phases	No. of Cycles	Form
1	I	12	1800	600	2200	3	60	P

TEMPERATURES AND INSULATION TESTS

	Temperature rise by thermometer Deg. C. Full load until constant	Temperature rise by thermometer Deg. C. 125% load 2 hrs.	Factory high potential tests between primary coils and frame A-C voltage for 1 min.	Full load speed R. P. M.
1	40	Without injury	6000	591

The overload temperature is based on making the overload run immediately following the full load run.

The efficiency and temperature rise are based on full rated voltage and frequency.

The temperature rise is further based on an ambient temperature of 25 deg. C., normal conditions of ventilation and an altitude of 1000 meters (3300 feet) or less; corrections for variations from this altitude will be made by changing the observed rise of temperature by one per cent for each 100 meters (330 feet) deviation in altitude above 1000 meters.

EFFICIENCIES, POWER-FACTORS AND OVERLOADS

	Full load		¾ Load		½ Load		Maximum running torque, % full load torque
	EFF.	P-F.	EFF.	P-F.	EFF.	P-F.	
1	94	89	93.5	87	91.5	82	225

ARRANGEMENT AND APPROXIMATE NET WEIGHTS

	Connection belted, direct geared, chain	No. of bearings	Motor complete
1	Direct	2	24300

Temperatures are to be taken by thermometer and rises will be based on a room temperature of 25° Cent. For room temperatures other than 25° Cent.

corrections will be made according to the Standardization Rules of the American Institute of Electrical Engineers.

Insulation tests will be in accordance with the Standardization Rules of the American Institute of Electrical Engineers.

The motor will be of the constant-speed induction type with horizontal shaft and phase-wound rotor. When running at full speed and full rated voltage motor will be capable of delivering its full rated horsepower. Motor will be furnished without base or coupling, but with two pedestal-type bearings and shaft extended for direct coupling to pump through a flexible coupling which is not included with the motor. The stationary member, or stator, will be the primary, and the rotating member, or rotor, will be the secondary.

Stator. The frame will be so proportioned that the laminations and windings will be supported with practically no deviation from a circle. The frame will be of the enclosed box type with open end shields, so constructed as to allow the free circulation of air around the winding.

The core will be built of high-grade thin sheet iron laminations carefully selected and treated so as to reduce core losses. It will be provided with slots on the inner circumference to receive the windings.

The winding will consist of copper conductors form wound, thoroughly insulated throughout their length, moulded to exact size before being assembled in the slots, and held firmly in place by means of wedges driven into grooves in the teeth. Each coil will be a complete unit in itself, so that in the event of any coil being injured it can be removed readily and another substituted by removing a few adjacent coils.

The insulation of the coils will consist of layers of fabric treated with a suitable insulating compound. Special treatment will be given this insulation which will make its quality such that it will be particularly able to resist oil and moisture and will not deteriorate when subjected to oil and moisture in connection with the temperatures herein specified.

Rotor. The rotor spider will be made of cast steel so designed as to hold the magnetic core rigidly in place. The magnetic core will be built up of high-grade thin sheet iron laminations selected and treated the same as specified for the stator. It will be provided with slots on its outer circumference to receive the windings.

The windings will consis of copper bars thoroughly insulated throughout their length and wedged tightly under the overhanging parts of the teeth, which will be so shaped as to prevent their being displaced by centrifugal force. The ends of the bars outside the slots will be further protected from displacement by being bound tightly upon the projecting ends of the flanges which hold the punchings in place. The windings will be so arranged that in the event of any bar being injured it can be removed readily and another substituted.

The insulation will consist of layers of fabric treated with a suitable insulating compound, the quality of which will be such that it will not deteriorate when subjected to temperatures herein specified, nor will any permanent injury result from exposure to dampness.

Collector rings. The collector rings will be of copper alloy placed in an accessible position between the bearing and the spider. The rings will be care-

fully insulated from each other and from the shaft, and so mounted that the air can freely circulate around them giving thorough ventilation. The brushes will be pressed against the rings by springs in such a manner as to give a uniform pressure. Provision will be made for short circuiting the collector rings on the inside surface when the motor has come up to speed, and at the same time the brushes are lifted from the collector rings, thus eliminating wear and resistance and brush contact losses.

Shaft. The shaft will consist of one piece forged steel, accurately finished to gauge. It will be of sufficient size to perform the work specified and prevent nundue deflection.

Bearings. The bearings will have cast iron shells lined with hard babbitt and will be of the ring oiling type. The bearings will be self-oiling and self-aligning and will have ample surface to insure cool running. The oil reservoirs will be capable of holding a liberal supply of oil, and convenient gauges for indicating the height of the oil and outlets for drawing it off will be provided.

Control. A drum type controller will be mounted back of the switchboard and will be connected to a handwheel on the front of the panel through bevel gearing. This controller will cut out the resistance in the rotor circuit in fourteen steps. The resistance will be of the cast grid type.

Interlocks will be provided so that, in the event of the oil circuit breaker being tripped on overload or low voltage, it cannot again be closed until the controller has been brought to the "off" position and the short circuit removed from the brushes.

The acceptance test was run on May 28 and 29, 1918. All tests were conducted strictly according to the requirements of the contract. No essential compromises were necessary.

Three sets of watthour meters, each complete with suitable current and potential transformers, were read during the test. In addition a portable set of standard instruments was used, including two single-phase watt-meters, one polyphase wattmeter and one voltmeter, four ammeters and portable current and potential transformers.

Two sets of calibrated gauges were used to measure the discharge head and the suction head respectively.

The Venturi meter was accepted as correct, as provided for in the contract. The manometer was checked and found correct.

All instruments were checked and calibrated in the presence of proper witnesses.

The electric meters were calibrated by means of portable standards read during the test, under the conditions of current, voltage and power-factor obtaining during the official test. As a result the master constant of the watthour meters was readjusted by eight-tenths of one per cent.

The electric motor and electric equipment were found to satisfy the conditions prescribed by the contract as to efficiency, power factor, temperature rise, slip and starting current, as well as to mechanical features.

The motor efficiency, determined under the conditions was	95.5 per cent
Slip	1.1 per cent
Temperature rise	33.5 degrees
Power-factor	90.0 per cent
Starting current (in terms of full load current)	113.0 per cent
Average line voltage	2406.0 volts

The pump and accessories satisfied the conditions of the contract as to performance, workmanship and material.

The combined efficiency of the set was found to be 82.1 per cent.

During the 28 hours official test the following conditions obtained:

Gallons pumped	37,719,500.00
Or at the rate of 32,331,000 gallons per 24 hours.	
Total dynamic head (average)	251.56
Discharge head (average)	235.13
Suction head (average)	16.43
Kilowatt-hours used	36,307.20

The contract provides for a bonus for efficiencies exceeding 76 per cent while the set is running at 30,000,000 gallons against a total dynamic head of 250 feet.

The accompanying curve sheet, figure 1, shows that the efficiencies at the other heads stipulated in the contract exceed in a similar way the guaranteed efficiencies. The service runs extending over a period of three months even showed an excess efficiency of over 5 per cent.

The average combined efficiency of the set taken to include the regular startings and to include the other conditions of varying load in regular service should not be less than 82.1 per cent by more than one per cent.

The City Meter and the Minneapolis General Electric Company's Meter have been adjusted so that they read almost exactly alike and are calibrated to agree exactly with their corrected readings taken during the official acceptance test of the pumping set. This is important, as the city is thereby enabled to purchase electric power for the pumping set on the same meter ratings as those upon which the pumping set was purchased.

In May, 1911, the city entered into a ten year contract with the Minneapolis General Electric Company, now the Northern States Power Company, by which the company agrees to furnish the necessary current of 2200 volts to operate two or more 20,000,000-gallon pumps at $4.00 per million gallons pumped against a dynamic head of 240 feet and a pumping set efficiency of 72 per cent, with the understanding that no current be used from 4.15 p.m. to 6.30 p.m., on week days during the months of November, December, January and February.

In November, 1916, a similar ten year contract was made with the same company for the operation of one 30,000,000-gallon pump.

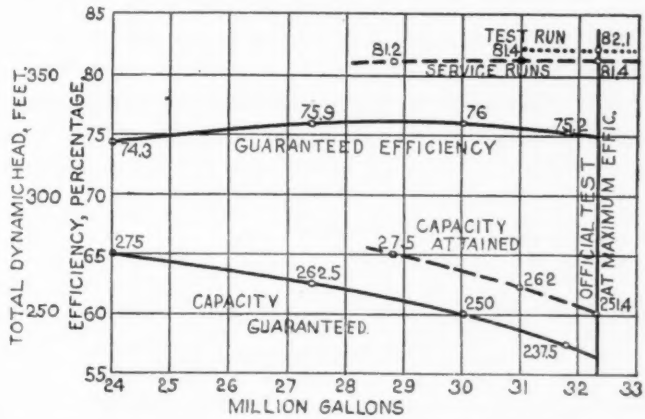

FIG. 1. GUARANTEED AND ACTUAL PERFORMANCE OF 30,000,000-GALLON ELECTRICALLY DRIVEN PUMP AT MINNEAPOLIS

The same rate of $4.00 per million gallons against 240 feet dynamic head and 72 per cent efficiency was provided in both contracts. At a different dynamic head and efficiency, the price per million gallons shall bear the same relation to the dynamic head and efficiency reached as the price above specified per million gallons bears to said 240-foot dynamic head at said 72 per cent efficiency. Both contracts also provided that the motor to be used by the city shall be capable of starting the pump in connection with which it is used from rest, when the pump is primed and when the check or gate valve in the discharge is closed, and of bringing the pump to full speed without drawing more than 150 per cent of full load current from the source of supply.

In 1910–1911, a 20,000,000 gallon Worthington pump was installed at the Northeast Pumping Station with a guaranteed efficiency of 72 per cent. During the first three months after the acceptance test of the new 30,000,000-gallon unit the following are the operating data at the Northeast Pumping Station:

DeLaval 30,000,000 gallon pump

GALLONS PUMPED	POWER COST	LABOR AND SUPPLIES	TOTAL	HEAD	EFFICIENCY
					per cent
2,797,400,000	\$3.68	\$2.27	\$5.95	250.06	81.4
Worthington 20,000,000 gallon pump					
421,340,000	\$4.15	\$2.27	\$6.42	250.57	72.3

During the first *nine* months, the following are the operation costs per million gallons.

DeLaval 30,000,000 gallon pump

GALLONS PUMPED	POWER COST	LABOR AND SUPPLIES	TOTAL	HEAD	EFFCIENCY
					per cent
6,526,350,000	\$3.72	\$1.77	\$5.49	255.80	82.48
Worthington 20,000,000 gallon pump					
1,771,930,000	\$4.33	\$1.77	\$6.10	257.80	71.4

At this same station there are also two triple expansion vertical A frame 15,000,000-gallon Holly pumps installed in 1903 and 1904 and tested in September, 1904. These pumps developed a duty of 162,000,000 foot pounds per 1000 pounds of steam (deductions made for slip). These pumps are in first class condition today.

During 1908 these two pumps furnished practically all the water for the city, 6,518,000,000 gallons against a head of 250 feet.

Cost of fuel* per million gallons	\$3.01
Cost of labor per million gallons	3.37
Other pumping expense	.35
Total	\$6.73

* Coal, Illinois screenings, \$2.11 per ton.

The cost today for the same performance would be

Cost of fuel* per million gallons	$7.03
Cost of labor per million gallons	5.22
Other expense	.49
Total	$12.74

* The same coal now costs $4.93 per ton.

These figures are very interesting.

The City of Minneapolis is of course very fortunate in having the long power contracts. This was made possible by an act of the Minnesota Legislature.

It also may be of interest to engineers to learn that a representative of the Worthington Company recently stated that he thought that his Company could make the 20,000,000 gallon pump reach a similar efficiency to that of the DeLaval pump by rather inexpensive changes in its impellers. If he can, the city will be glad to give him the chance.

WATER CONSUMPTION IN ARMY CAMPS

By George A. Johnson [1]

When the original sixteen National Army cantonments were planned, the designs of the water supply systems were based on an average consumption of 55 gallons per capita daily, with allowance for maximum rates of withdrawal equal to 2.85 times the average, the latter to cover peak loads. For the distribution systems wood stave pipe was used very extensively, although at some camps, notably Camps Funston and Dix, considerable cast-iron was employed. Table 1 is given here as an interesting exhibition of the varieties of pipe used and the lack of uniform use of any sizes. The constructing engineers were glad to get any pipe which would deliver the necessary quantities of water.

Table 2 shows the average daily water consumption in all the National Army cantonments. During the early months of 1918 the average daily allowance of 55 gallons per capita was exceeded by the actual consumption in all the cantonments except Camp Sherman and Camp Taylor.

The earliest activities of the Utilities Division were directed toward keeping the average water consumption within, or reasonably close to, the allowance of 55 gallons. In this it was successful to a marked degree, as disclosed by the decreasing consumption throughout the year 1918 as shown in figure 1. Lieutenant (now Captain) Walter H. Van Winkle was in direct charge of this work. It was necessary to conserve water and curtail waste for the reason that unlimited use of water would leave no reserve for fire protection, shut-downs, etc. It was furthermore wise for obvious reasons of economy. Undue leakage in the pipe distribution system, wanton or careless waste and defective plumbing fixtures, are all remediable without deleterious effect on the service.

Posters were printed urging the troops to conserve water, but probably the best results of the campaign followed vigorous plumb-

[1] Colonel, U. S. A., Utilities Division, Construction Division of the Army.
Discussion of this paper is requested, and should be sent to the Editor.

ing inspection and repair of leaks. It also developed during this campaign that the one sure method of reducing water consumption was not by moral suasion or punishment for infraction of orders, but by prompt repair of leaks disclosed by constant inspection, and by setting up mechanical barriers against the undue use of water by the troops.

Orders were issued prohibiting the dangerous practice of partially closing valves on main lines to reduce pressure, for without prompt

TABLE 1

Water Distribution Systems in National Army Cantonments

CAMP	LOCATION	TOTAL MILES OF PIPE	PERCENTAGE OF DIFFERENT SIZES						
			4-inch	6-inch	8-inch	10-inch	12-inch	14-inch	16-inch
Custer	Michigan	14.7	0	26	12	25	37	0	0
Devens	Massachusetts	25.4	2	18	57	13	10	0	0
Dix	New Jersey	19.3	0	23	43	0	14	0	20
Dodge	Iowa	16.0	0	32	18	15	29	6	0
Funston	Kansas	19.8	14	15	47	8	13	2	1
Gordon	Georgia	15.4	3	19	38	28	10	1	1
Grant	Illinois	19.4	0	21	23	30	24	1	1
Jackson	South Carolina	26.2	1	32	45	1	7	0	14
Lee	Virginia	20.7	0	25	6	19	28	0	22
Lewis	Washington	22.7	4	27	9	29	14	17	0
Meade	Maryland	20.3	0	23	30	20	26	1	0
Pike	Arkansas	25.6	1	16	45	14	2	0	22
Sherman	Ohio	15.1	2	23	36	33	2	4	0
Taylor	Kentucky	16.8	1	15	44	17	23	0	0
Travis	Texas	17.2	5	54	24	0	12	0	5
Upton	New York	21.2	4	29	14	36	2	14	1

re-opening of such valves disaster might follow in consequence should fire break out in the camp. One most successful means of reducing waste was the use of some sort of device in each faucet and shower head whereby rates of delivery by these fixtures were reduced. For this purpose the most popular method was the insertion of a tapered lead plug with an orifice varying from $\frac{1}{16}$-inch to $\frac{3}{32}$-inch in size, depending on the pressure. This was inexpensive and easily installed and was markedly effective. The lowering of float balls in toilet flush tanks produced a large water saving.

TABLE 2

Water Consumption in the Sixteen National Army Cantonments

MONTH (1918)	AVERAGE DAILY MILITARY POPULATION PER CAMP	TOTAL DAILY MILITARY POPULATION	TOTAL DAILY WATER CONSUMPTION	AVERAGE DAILY PER CAPITA WATER CONSUMPTION
			million gallons	*gallons*
January	28,000	449,000	31.9	71.2
February	27,300	436,000	29.6	67.6
March	28,900	463,000	34.7	75.0
April	30,400	487,000	30.8	63.2
May	34,800	559,000	34.2	61.3
June	35,100	561,000	34.9	62.0
July	36,400	583,000	35.1	60.2
August	40,100	643,000	35.4	55.0
September	42,400	679,000	33.8	50.0
October	37,031	592,500	33.4	53.0
November	35,625	570,000	31.8	56.7
December	29,312	469,000	29.8	66.1
Averages	33,780	540,000	33.0	60.9*

* Weighted.

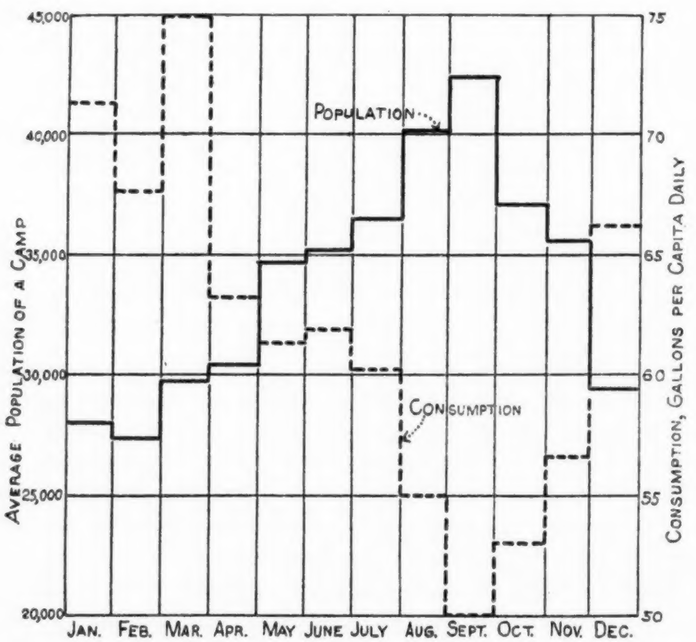

FIG. 1. AVERAGE MONTHLY POPULATION AND WATER CONSUMPTION IN AN ARMY CANTONMENT DURING 1918

Explanatory of the data in table 3, it will be noted that as the troop population decreased the per capita water consumption increased. This was due to a variety of reasons, among which were:

a. Overhead consumption which was a fairly constant factor; and overhead leakage. It might happen that the withdrawal of troops and consequent reduction in personnel would not be accompanied by a proportional reduction in the number of animals. These comments apply to conditions prior to the armistice.

b. Following the armistice, the morale of the troops relaxed and a material increase in water waste resulted, due to mischievous and in some instances malicious breaking of plumbing fixtures and from allowing taps to remain open and running. Furthermore, with demobilization activities going on and camp population decreasing in consequence, the absolute necessity of keeping the per capita consumption down became a matter of less importance.

The tabulation will show that the average per capita consumption in the sixteen National Army cantonments was about 61 gallons daily, instead of the prescribed 55 gallons. By and large it is not probable that this figure could be reduced under similar conditions, even in the face of the fact that the records from some camps are so good, notably Camps Devens, Dix, Dodge, Funston, Meade, Sherman and Taylor, and so comparatively unsatisfactory at other camps, notably Camp Grant. The high water consumption at Camp Travis was in some measure excusable, for the purchase cost was low and the supply practically without limit.

It is of particular interest, nevertheless, to note that the allowance of 55 gallons per capita was reasonable, and with a tighter distribution system and close attention paid to repair of leaks, as was the practice for the greater part of the year 1918, no difficulty should be experienced in keeping the per capita water consumption within the 55 gallon limit and still provide satisfactory water service for all uses in army establishments of this type.

TABLE 3

Average troop population and average daily consumption of water in gallons per capita in each of the sixteen National Army cantonments during 1918

CAMP	ITEM	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	AVERAGE
Custer	Population	23,000	22,000	17,000	25,000	29,000	34,000	24,000	30,500	39,500	42,000	37,500	32,500	29,700
	Consumption	92	97	106	77	61	54	67	54.5	41	50.5	58	62	64*
Devens	Population	28,000	26,000	28,000	33,000	38,000	44,000	28,000	38,000	45,000	44,000	40,000	39,000	35,900
	Consumption	73	70	69	51	47	41	56	53	43	46	51	71	54.3*
Dodge	Population	20,000	22,000	31,000	23,000	30,000	32,500	41,500	33,500	29,500	33,500	27,500	22,500	28,900
	Consumption	74	58.5	47.5	57	57	54	50.5	53.5	47	42.5	40.5	43.5	52.7*
Dix	Population	23,000	21,000	27,000	36,000	42,000	39,000	53,000	56,000	53,000	38,000	27,000	20,000	32,250
	Consumption	68	67.5	57	60	57	49	43	42	49	53	66	70	53.8*
Funston	Population	29,500	28,500	27,500	31,500	36,000	21,500	28,500	37,500	38,000	41,000	45,000	39,000	33,600
	Consumption	63	58.5	49	46	49	70	53.5	51	43	49	46	50	51.3*
Gordon	Population	35,000	33,000	35,000	33,000	34,000	37,000	40,000	43,000	42,000	32,000	26,000	20,000	34,200
	Consumption	71	70	68	67	68	64	63	59	57	64	66	79	65.5*
Grant	Population	26,500	25,500	29,500	29,500	33,500	34,000	40,000	39,500	40,500	42,000	33,000	29,500	33,580
	Consumption	124.5	124	100	98	85	81	72.5	69.5	57	70	85	98	85.6*
Jackson	Population	21,000	20,000	24,000	29,000	30,000	40,000	43,000	42,000	45,000	35,000	33,000	32,000	32,800
	Consumption	90	85	75	60	69	64	59	57	50	57	54	60	62.5*

Lee	Population	27,000	30,000	30,500	35,000	39,000	45,000	50,000	47,000	52,000	49,000	40,000	40,000	40,400
	Consumption	80	74	72	68	73	55	48	57	52	59	65	62	62 2*
Lewis	Population	33,500	31,500	27,500	32,000	41,000	43,500	26,000	30,500	39,500	36,500	35,500	32,500	34,100
	Consumption	59	63.5	68.5	59	58	59	73.5	67.5	60	55	55	51.5	60.4*
Meade	Population	35,500	30,000	32,000	30,000	37,000	41,000	32,000	43,000	44,000	44,000	44,000	38,000	37,600
	Consumption	58	65	58	58.5	57	48	58	48	43	48	44	49	52*
Pike	Population	31,000	29,000	31,000	29,000	35,000	30,000	40,000	48,000	55,000	55,000	40,000	29,000	33,500
	Consumption	64	61	62	65	67	87	62	40	38	41	57	76	58.9*
Sherman	Population	33,000	33,000	27,000	33,500	37,500	23,500	35,500	39,000	34,000	36,500	34,000	22,000	32,500
	Consumption	53.5	44	47	40.5	42.5	57.5	52.5	49.5	47.5	50	53	71	49.9*
Taylor	Population	25,500	25,500	26,000	22,500	30,000	28,500	34,000	45,000	54,500	49,500	46,500	27,000	34,500
	Consumption	41.5	46.5	52.5	59.5	56	68	57.5	46.5	36	42	42.5	56	48.6*
Travis	Population	29,000	28,500	32,000	30,000	38,500	28,500	29,500	32,500	37,000	34,500	35,000	27,000	31,800
	Consumption	90	93.5	82.5	73.5	64	86	81	80	59	69.5	67	89.5	77*
Upton	Population	32,000	32,000	36,000	32,000	31,000	38,000	37,000	38,000	39,000	30,000	26,000	19,000	32,500
	Consumption	69	64	67	73	65	58	49	46	44	52	57	70	58.6*

* Weighted.

THE WATER SUPPLY SYSTEM OF CAMP McCLELLAN, ALABAMA[1]

By Maurice R. Scharff[2]

The water supply system of Camp McClellan, Alabama, described in this paper, is the system designed and installed for the originally authorized national guard camp for one division, constructed during August, September and October, 1917, during which period the author served as engineer in charge for Morris Knowles, Inc., supervising engineers. Subsequently, after the author was called to active service with the Corps of Engineers in France, extensions and additions were made to the distribution system; and at the time of the signing of the armistice, a project for a new impounded supply and the reconstruction of a considerable part of the system, to take care of a proposed enlargement of the camp, was under consideration. But, in general, no extensive changes were made in the supply works or distributing reservoir, so that substantially the works described herein have continued to serve the camp up to the present time.

The basic requirements for the water supply of the camp were largely fixed by the instructions to the Constructing Quartermasters issued by the Engineering Division of the Department of Cantonment Construction at Washington. This included the specification that the system should be capable of delivering an average of 30 gallons per capita on any one day and a maximum for one hour of 2.85 times the average. It was, of course, expected that the quality of the supply should be unobjectionable.

The original instructions covered the construction of a camp to contain about 34,000 men, which at 30 gallons per capita, would require an average daily supply of 1,020,000 gallons per day. It was not clear whether the instructions contemplated that this

[1] Read before the Central States Section, Discussion of this paper is requested, and should be sent to the Editor.

[2] Assistant Chief Engineer, Morris Knowles, Inc., Pittsburgh; recently Captain, Engineer Corps, A. E. F.

should be the average or the maximum daily consumption to be provided for; or, if for the average, what allowance should be made for seasonal and weekly variation in daily draft. It was believed, however, that there would be a substantial variation in daily draft, and it was finally concluded that the safest plan would be to take the prescribed per capita allowance as an average and make provision in the design for an excess of 50 per cent on the day of maximum draft. The system was, therefore, designed to provide a maximum daily delivery of 1,500,000 gallons.

The rapid study of the situation made upon the author's arrival on the ground on June 16, 1917, led to the conclusion that the only source from which a sufficient supply could be obtained within the time limit fixed by military necessity was the system of the Alabama Water Company, which supplied the City of Anniston.

This system takes its supply from Coldwater Springs, located about seven miles southwest of Anniston. It is one of the great limestone springs of the lower Appalachians, with a minimum flow of about 25,000,000 gallons per day. The pumping station, at the beginning of the construction of the camp, contained two old Holly steam pumps, each of 3,000,000 gallons per day capacity (one of which was removed and sold for scrap in August, 1917, while the other was held in reserve as a spare); and a 10-inch Worthington turbine pump, direct connected to an electric motor and designed to deliver 3,000,000 gallons per day against a pressure of 165 pounds per square inch.

The pumping station delivered water through a 20-inch cast iron main to a 7,000,000-gallon distributing reservoir, from which a 16-inch main supplied the distribution system. A 10-inch main of the distribution system supplied an industrial plant and a small village at Blue Mountain, and on this main, the nearest to the camp site, it was determined to make the connection for the camp supply, reinforcing the distribution system sufficiently to deliver the required quantity to this point.

The new construction included the installation of three belt-connected, electric-motor-driven centrifugal pumps in the Coldwater pumping station of the water company, a Buffalo pump designed to deliver 1050 gallons per minute against 430 feet head, an Alberger pump designed to deliver 1035 gallons per minute against 430 feet head, and a Hill pump designed to deliver 1750 gallons per minute against 430 feet head; the construction of a 10-inch reinforcing main

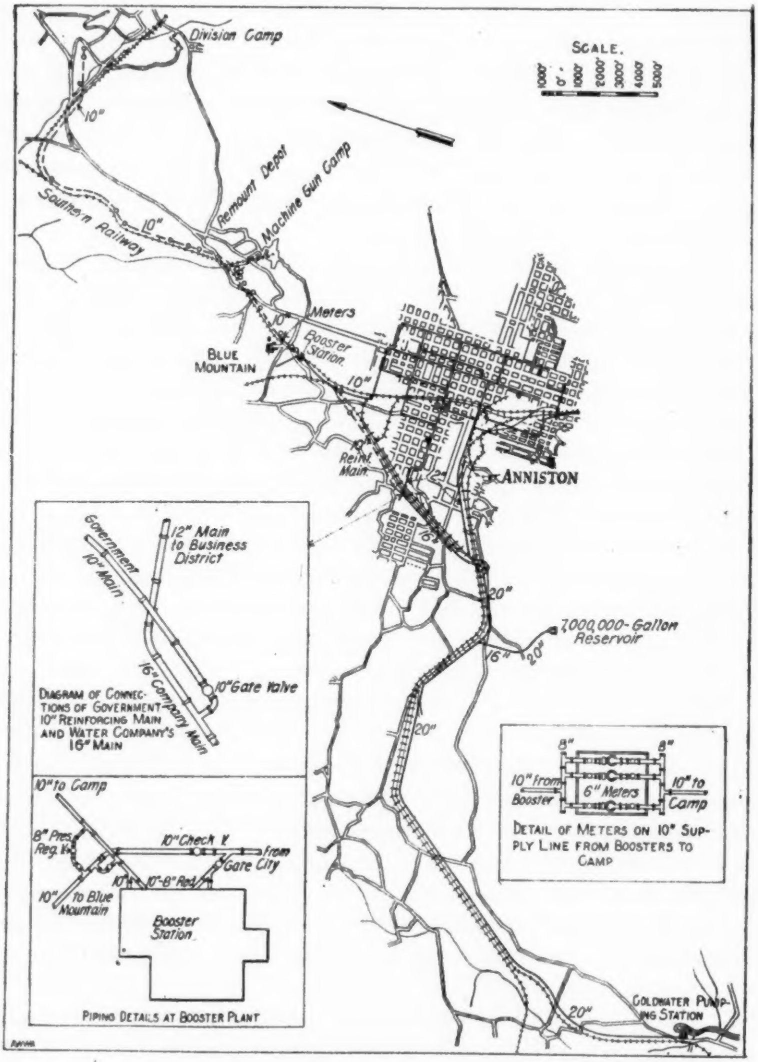

FIG. 1. MAP SHOWING REINFORCEMENT AND EXTENSION OF THE ALABAMA WATER COMPANY'S SYSTEM BY THE WAR DEPARTMENT TO SUPPLY CAMP MCCLELLAN

6500 feet long, tapped into the water company's 16-inch main under pressure by means of a Smith tapping machine; the installation of a booster pumping station including three pumps, two of them (one a Hill, the other an Alberger) designed to deliver 500 gallons per minute each against 225 feet head and direct-connected to electric motors and a Buffalo pump, originally designed to operate at 1500 revolutions per minute and to deliver 1050 gallons per minute against 430 feet head, but belt-connected to an electric motor so as to operate at 1040 revolutions per minute and to discharge about 1000 gallons per minute against 225 feet head; the construction of a 10-inch cast iron force main 25,500 feet long; a distribution system for the divisional camp, the base hospital and the remount depot, containing 5790 feet of 10-inch pipe, 8870 feet of 8-inch, 61,960 feet of 6-inch, 2560 feet of 4-inch, 5080 feet of 3-inch, and 98,975 feet of smaller service lines; and a distributing reservoir, of 800,000 gallons capacity, originally designed to be lined with concrete, but constructed without lining on account of the unusually impervious character of the material in which it was excavated.

The conditions under which this work was done illustrate very well the controlling influence exercised by the time element in the cantonment construction work, and the extent to which designs and construction methods were controlled by considerations other than those which would apply in ordinary practice. The choice of the source of supply, for example, was absolutely limited by the time element. For, while later studies for the enlargement of the camp went into the possibilities of spring supplies, deep well supplies and impounded surface supplies, all of these had to be ruled out from the first consideration because of the obvious impossibility of assuring a supply from these sources prior to the arrival of the first troops.

The designs of the reinforcing and force mains were similarly affected. The water company's distributing reservoir was located at such an elevation as to give a static head at the camp site of over 50 pounds per square inch. The largest size of pipe which there was any possibility of obtaining within the requisite time, however, was 10 inches in diameter, and this size was selected on the basis of possible deliveries, without regard for the fact that theoretical computations appeared to indicate that a larger size might have been more economical. With this size of pipe, it was estimated that, at the assumed maximum daily rate of draft, 1,500,000

gallons per day, a pressure of not less than 30 pounds per square inch could be maintained at the site selected for the location of a booster station, which would be sufficient to maintain domestic service to the sections of the city and suburbs dependent upon this portion of the distribution system; and that by raising the pressure at the booster station to 130 pounds per square inch this quantity could be delivered to the camp with a resultant pressure at the camp site of 50 pounds per square inch.

Another feature of the Camp McClellan water works system which was controlled entirely by the time limit set for completion was the location of the 10-inch supply main, which followed, for the greater portion of its length, the existing tracks of the Southern Railway and the connecting line constructed for the service of the divisional camp. A location approximately 4500 feet shorter would have been available by following some of the existing country roads, but as these roads were practically impassable for heavy traffic, it would have been impossible to complete the delivery of the pipe within the time limit fixed by military necessity.

The necessity for giving the time element this controlling influence is clearly explained by the early history of the water supply construction. When the author arrived upon the ground on July 16, the site was not yet selected, although arrangements had been completed by the local Chamber of Commerce for the purchase of a large tract of property which offered a number of possible locations for a divisional camp. Within the ensuing two weeks the site was selected, the general plan of the camp outlined, railroad connections arranged for and construction upon the first unit started by the contractor. During the same time, the decision was reached to secure a water supply by connection to the mains of the water company supplying Anniston, by the construction of a booster station and reinforcing and supply mains 32,000 feet in length. About August 1, word was received that water must be made available in the camp for troops who would commence to arrive on August 15. Delivery and distribution of the pipe commenced the same day; pipe laying started on August 4; and although two days of rain intervened upon which no pipe was laid, the line was tied in and an ample supply of water for the first troops delivered to the camp by August 15.

The rapid delivery of the pipe required for the 32,000 feet of reinforcing and supply mains and their completion and connection

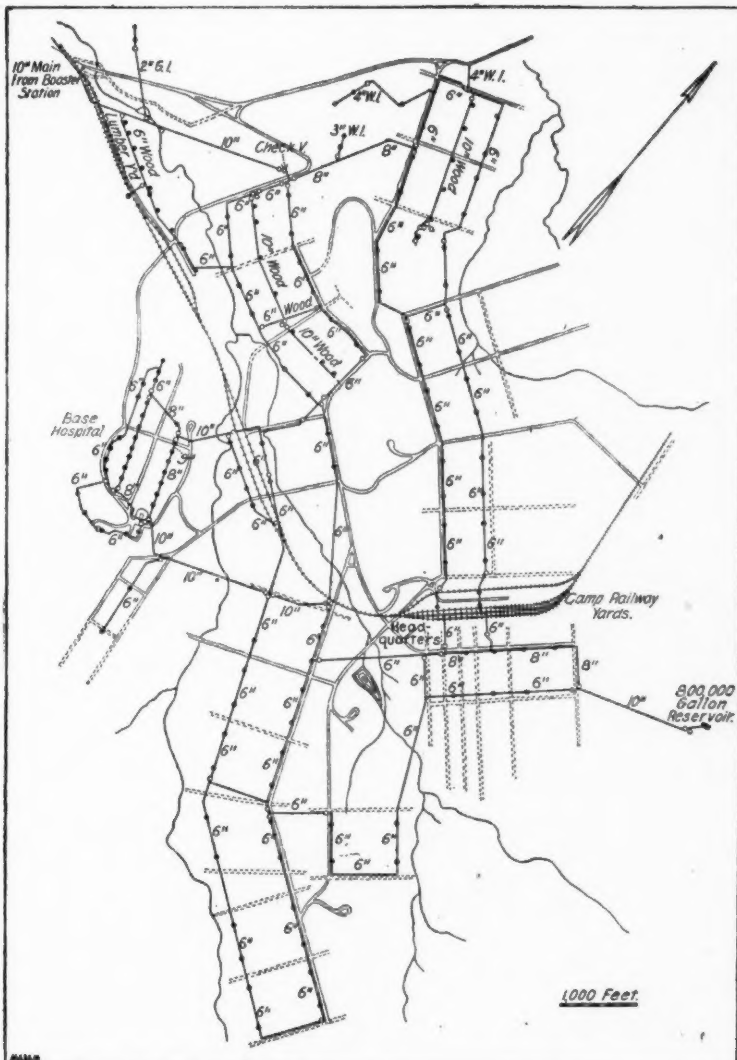

FIG. 2. THE DISTRIBUTION SYSTEM FOR SUPPLYING WATER IN CAMP McCLELLAN

within ten working days must be ascribed largely to the authorization by the Washington office of the use of cast iron pipe and to the coöperation of the superintendent of the Anniston Foundry of the United States Cast Iron Pipe & Foundry Company. This company furnished from its Anniston, Chattanooga and Bessemer foundries all of the pipe in the line, except about 5000 feet of Universal pipe, and when completed the line contained, in addition to the Universal pipe, standard bell and spigot pipe of Classes A, B, C and D; standard gas pipe of two weights; and several thousand feet of 9.8-inch (25-centimeter) pipe of special quality which had been cast for the Argentine Republic. Not only did the foundry superintendent devote a large part of his time to securing these deliveries, but, in addition, he arranged for the use of the foundry pipe crane, much of the time under his personal supervision, for distributing over 20,000 feet of pipe along the trench from the railroad, with maximum rapidity and a minimum of breakage.

The service of the Anniston Foundry was also of the greatest value in securing rapid delivery of special castings, and even of flanged castings. On one occasion, while additional pumps were being installed in the Coldwater pumping station of the water company, a crack was discovered on a Sunday afternoon in a 16 by 10-inch reducer. The superintendent of the foundry was reached on the telephone and on Monday morning the completed casting, faced and drilled and still hot from the molds, was delivered at the pumping station over 8 miles of country road. This service permitted the casting to be placed in position and pressure restored by 4 o'clock Monday afternoon.

The early operations of the Camp McClellan water works system produced interesting examples of the difficulties due to the peculiar character of water consumption in military encampments. The pressure from the city distributing reservoir was sufficient without booster pumping to deliver the quantity necessary for night use and the requirements of the first troops which arrived on August 15; but after the completion of the installation of the first booster pump on August 19, it was necessary to operate the booster pumping station throughout the day, every day, from about 5 o'clock in the morning to 7 or 8 o'clock in the evening. This method of operation was sufficient to permit the continuous maintenance of satisfactory service after the completion of the camp distributing reservoir on October 13; but until that time much difficulty was experienced in

maintaining service, due to rapid fluctuations in pressure resulting from the large variations in hourly use. Prior to the completion of the reservoir, it was found impossible to maintain pressure in the higher parts of the camps immediately after the noon mess hour daily, when the mess kits were being cleaned, and for the greater part of Wednesday and Saturday afternoons when there was no drill, and when most of the showers in the camp could be found running either for bathing or washing purposes. These difficulties were especially great during the period August 19 to September 11, when the booster station was pumping into a closed system, not only without storage but without adequate pressure relief. During this period a direct telephone connection was maintained between the booster pumping station and the engineering office at the camp and during certain portions of the day, an observer was stationed at each point watching the pressure gauges, the observer at the camp directing the operation of the suction valve on the pump so as to control the pressure at the camp. Even in spite of this precaution on several occasions sudden pressure jumps occurred, and breaks in the supply main resulted once or twice.

On September 11 a pressure regulating standpipe of 10-inch pipe supported by a wooden scaffolding was constructed and carried up to the elevation of the distributing reservoir, then under construction. At the top of this standpipe an elbow and a 6-inch valve were leaded in, and this overflow at the highest point of the system proved a reasonably effective pressure regulator, although at times some attention to the pressure gauge at the camp and control by regulation of the suction valves at the booster station were necessary.

The reservoir to which reference has been made, was made necessary by the fact that the maximum hourly rate at which the standards of the Cantonment Construction Division required water to be delivered (2.85 times the daily rate) was approximately twice the maximum capacity of the 10-inch pipe line. The reservoir was located on the opposite side of the distribution from the entrance of the force main, and connected by a 10-inch pipe, so that after the reservoir was in service, the maximum demand could be met without serious fluctuations in pressure.

The original plans for the reservoir called for a structure 50 by 100 feet at the bottom, with side slopes $1\frac{1}{2}:1$ and a capacity of 500,000 gallons, the bottom and slopes to be concrete lined. After starting excavation it was found that the material was a very hard,

stiff clay, practically impervious to water, and it was decided to omit the concrete lining and to change the side slopes from $1\frac{1}{2}:1$ to $2:1$, giving additional capacity. The original intention was that the reservoir should be filled only to the line of the natural surface of the ground, but on account of the excessive width of the filled embankment and the practically impervious nature of the material, it was later found possible to fill the reservoir to a height of 2 or 3 feet above the elevation originally intended. On this basis the capacity of the reservoir may be taken at 800,000 gallons. Wherever rock boulders projected above the finished lines of the reservoir, instructions were given that they should not be removed, in order to prevent the disturbing of the finished slopes. The construction of the reservoir was begun on August 25 and completed October 13.

In some respects there was much similarity between the cantonment water supply work and the work upon which the author was subsequently engaged in the Water Supply Division of the Office of the Director of Construction and Forestry of the American Expeditionary Forces in France. In both cases the time element was of far greater importance than the ordinary considerations controlling engineering design. In one respect, however, the cantonment construction work was very much more satisfactory and enjoyable than that in France. Reference is made to the availability and orderly rapid delivery of material made possible by the efficient coöperation of the Washington office, as compared with the discouraging impossibility of securing materials which resulted from the tonnage shortage during the early days of the history of the American Expeditionary Forces.

THE WATER SUPPLY PROBLEM IN A COMBAT DIVISION [1]

By Lucius A. Fritze [2]

It was the good fortune of the author to have participated in the World War as Water Supply Officer for the famous 42d or Rainbow Division, as well as to have been Commanding Officer of the Divisional Field Laboratory, and later, the Water Supply Officer for the American Third Army, the Army of Occupation in Germany. It is upon experiences gained during this service that he is able to coordinate his impressions of the task of supplying water to an army division in active service.

A brief résumé of the life of the Rainbow Division may not be amiss, for from it can be judged the experience of practically all other American units which served at the front. This division was the third complete divisional organization to land upon French soil. It was organized at Camp Mills, Long Island, N. Y., in August and September, 1917. It sailed for Europe in the middle of October, and all the organizations of the division had been debarked in France early in November. Then came several months of training, until the early part of February, mastering the finer points of modern warfare under the instruction of the French. After this the real work commenced, with 110 days without relief in the trenches of the Luneville and Baccarat sectors.

On March 20 the Germans had commenced the desperate and enormous effort to reach the French capital, and the British and French armies shook under the strain. On the 3d of July the 42d went into its first major operation in the chalk-fields of the Champagne. Here the division remained in the trenches until the morning of the fifteenth of July, when the last great offensive of the German army broke against the French and the Americans. After

[1] Read before the Iowa Section at Mason City, October 22, 1919. Discussion of this paper is requested and should be sent to the Editor.

[2] With Wallace & Tiernan Co., Inc., 349 Broadway, New York; recently Captain, Sanitary Corps, A. E. F.; Water Supply Officer, Rainbow Division; Water Supply Officer, Army of Occupation.

four days of battle this effort was halted and the division was transferred to Chateau Thierry, in the great counter-offensive which was launched by the Allies on the morning of the 18th. Here ensued almost one month of continual horror because of the sickening heat, the frightful destruction in both life and property, and the difficulties attending the transportation of almost all necessities of life to the men in the fighting line.

From this engagement the organization went to a rest area for five days, and then, after a march of ten days, to immediate participation in the advance and taking of the hitherto impregnable St. Mihiel salient. This battle lasted for four days, but the division spent until the 30th of September holding the front line trenches. Then came the supreme American effort in the Argonne Forest, during which the Rainbow fought twice and ended its fighting history on the 11th of November, by capturing the keystone position of the German Army, the City of Sedan.

After a few days of much needed rest, the long march into Germany commenced, and by the middle of December, the troops took position on the left bank of the Rhine as elements of the Army of Occupation. There followed four months of welcome inactivity until orders in April sent the Division to the United States.

From this résumé it may be seen that the problem of supplying water of a potable character to an infantry division during its many phases of activity is in itself unique. In this organization of 28,000 men, sometimes scattered over a wide area, and then again congested into a close formation, it was necessary to have a definite organization with prescribed responsibility to maintain the certainty of pure water for both men and animals.

The life cycle of a division may conveniently be divided into five phases, represented as follows: first, in the training area; second, on the march; third, in stationary trench warfare; fourth, in rest area after action; and fifth, in active battle.

To properly present the various conditions that confront the Water Supply Officer of a Combat Division, it is necessary to take up each of these phases separately. Thus, in the first phase, which is the life in the training area or camp, the work of this officer is of a comparatively simple nature, since the water is usually taken from the mains of the nearest city or town which has a potable supply, or from a developed local supply in the camp. As a rule, such work is cared for either by the Quartermaster Corps or the Engineer Corps.

The water is purified in the same manner as in the best municipal plants, and only requires a periodical examination by the Water Officer to assure its potability. It so happened in the training areas in France that the troops were billeted in a large number of small towns, since it was impractical to construct at that time cantonments for so large a body of troops. In this case, with so many sources of supply exposed to surface pollution, it was necessary to investigate each and every supply used by the men.

The Army supplied each company, 250 officers and men, with two canvas water bags, commonly known as Lyster bags. Previously issued orders required that all water used by the men for drinking purposes should be sterilized in these bags. Within the division the organization supervising this routine was the Divisional Field Laboratory. Sufficient personnel from this unit was constantly engaged in the investigation of the sources of supply and making the necessary chemical and bacteriological examination of the water. Since it was impossible for the men of this organization to oversee this at all times, it was the duty of the battalion medical officer to insure that the orders in this regard were carried out, and that one man from each company was assigned to the duty of filling these bags and taking care of the sterilization. By this means, in the training areas, potable water was constantly available for all the men.

The second phase of a division's activity is on the march. During such periods it is impossible for one man to investigate each source of water, so the responsibility for the selection of sources rests with the medical officer or officers on duty with the individual organization. If question arose as to the desirability of using certain water, the divisional Water Officer was called for consultation. In France, of course, the roads had all been traversed at one time or another by the French Army and the French medical and sanitary units had labeled most of the water supplies as to the safety or danger attending their use, but since in many cases these signboards had been put up as much as two years before, it was necessary to make a general survey to determine whether or not the water was still potable. A simple chemical procedure using starch iodide solution enabled the investigating officer to determine roughly if any great amount of pollution was present.

These two briefly described phases have entailed no great amount of effort and no insurmountable obstacles to the Water Supply Officer because the source of water has always been in those towns or villages

where members of the civilian population were living and using the water daily, thus giving some guarantee of its purity. The next phase, however, or the phase of trench warfare, presented quite a different aspect. Here the civilian population had been evacuated from within a distance of five miles of the front line trenches, the towns were in most instances damaged or destroyed by shell-fire and many of the water sources covered by debris or grossly polluted by passing troops. Into this area representing approximately six to nine miles of trenches and extending eight miles to the rear, were stationed 28,000 men. It may be positively said that there was not one single source of pure drinking water to be found in the area of the trenches. All were condemned at first hand. Open springs were subject to two sources of contamination, one from fecal matter, and the other from gas shells which had impregnated the soil thereabout.

This situation presented a problem rather difficult to overcome, but three methods were found which were successful. The best wells near the trenches were lined with concrete and a heavy concrete cover placed over the top to protect them from gas shells. This method enabled the troops to obtain satisfactory water, if it was sterilized, quite near the front. Since, however, these wells afforded water only to the troops in the immediate locality, it was necessary to have pipe lines laid, by Engineer troops, from known water sources back of the zone of shell fire, to make up for the deficiency of supply. Again a narrow gauge railway permitted water, sterilized in the rear, to be brought up to various points of advantage along the front. Animal-drawn water wagons then took it the intervening distance to the company kitchens. By these means water for the Lyster bags which were hung in the rear trenches was obtained. The troops in the line filled their canteens from these bags.

Troops leaving one of these nerve-racking, front-line sectors after having been under an intense strain for a varying period of time, went to the rest area. Here the situation was much the same as in a training area, for water was easily obtained, but the condition of the men after such a gruelling experience was very different. They were worn out by sleepless days and nights, constantly on the alert for eventualities, jarred by the concussion of exploding shells, and presented an easy prey for pathogenic bacteria to which, in an ordinary condition of health, they would have had a considerable resistance. Hence the problem of supplying a safe drinking water assumed a doubly important aspect. Sanitary surveys, bacteriological exam-

ination, chemical examination and practically every known means of water control were used. Even with all precautions and care being employed, it was almost impossible to prevent the occurrence of sporadic cases of illness due to the drinking of polluted water in the rest areas.

We have seen in a general way the problems encountered in maintaining sufficient and safe water for a Combat Division during its ordinary existence. We now reach the time when the organization puts forth its supreme effort in battle. As a body of troops swung along to take up position in a drive against the enemy, the men were in a nervous mood. Sometimes thoughtlessly, and then again with the "don't care" attitude, all the precautionary measures for the sterilization of the drinking water were not fully carried out. The water supply as found along the front was used. If the Engineers had developed and established definite water points with proper sterilization, these points were the sources of supply. If, however, very little preliminary work had been done in the preparation of suitable sources, any satisfactory supply was used.

With the heavy concentration of men found in a battle line, wherein a complete division occupied a sector approximately two miles in width, all the water supplies were grossly polluted despite all precautionary measures. Unsterilized water was used. When the zero hour was reached and the first waves of infantry went over the top, the problem of maintaining satisfactory drinking water became most difficult. With the terrible destruction of life, wastage, and decomposition, it was an almost impossible task to obtain it. Again, those supplies which looked most attractive might have been poisoned by the enemy, though in the experience of the author no source was found by him which seemed to have been deliberately poisoned. This remarkable circumstance, that all waters were not intentionally poisoned, seemed to be due to the fact that the Germans had been on the offensive so long that when on the defensive they did not appreciate the seriousness of their position until too late.

After the troops had passed over that desolate stretch of ground called "No Man's Land," and had extended the lines several miles beyond, the problem of getting the necessary water purification supplies across that waste presented great difficulties. In the meantime, the task of checking water supplies for the presence of free poisons and maintaining potable water for the troops was practically impossible. With the water supply organization established in the Rain-

bow Division, which made every conscientious effort that suggested itself or could be suggested, and could not realize perfect success, the enormous obstacles attending this may be appreciated. Nevertheless, by untiring effort and investigation, both by night and day, information was gained by the laboratory which proved to be of immense aid to the troops even in the heat of battle. And there can be no doubt, that the very presence of men in the field who were continually alert to the dangers of contaminated water, and who were constantly warning the medical officers of real and suspected dangers, had much to do with the attention which was given by the troops to this matter. In this way the Divisional Field Laboratory justified its existence at the scene of an active engagement.

Usually each soldier carried sufficient water to last for the first twenty-four hours of battle, but with canteens being punctured and lost, there were times when the men were forced by their extreme thirst to drink the water from shell holes, which often contained the corpses of both dead men and animals. Sometimes, as in the Battle of Chateau Thierry, when the Engineers did not succeed in developing water points nor a potable supply from the available sources, this water from the shell holes was consumed for a number of days in succession. The consequence was a heavy outbreak of diarrhoea and dysentery. It may be said that the typhoid and paratyphoid prophylaxis saved our army from most serious epidemics of these diseases. As it was, in some battles, upwards of half a command was afflicted with diarrhoea of a more or less serious nature, and many were incapacitated for duty.

Since this battle was fought during the months of July and August, in a period of intense heat and untold swarms of flies, a vicious cycle was established; made up by the primary drinking of grossly polluted water, then a severe diarrhoea, and the completion of the cycle by the plague of flies which carried the infectious matter to the foodstuffs. To combat this condition with the very limited facilities in the field, it was necessary to adopt an emergency measure, which may not meet with the approval of all sanitarians, but which proved itself to be a successful remedy at the time. This consisted in adding to the water what would have been considered in ordinary times a gross excess of chlorine, approximately 12 parts per million. Although such a large amount of this substance caused the water to be unpalatable, its use at meal times so sufficiently sterilized the food as to prevent the infection of those who were still healthy. The records

of the Medical Department of the Division will bear out the statement that the diarrhoea was halted. In fact, this method proved so valuable that its later use with even more strongly chlorinated water, was adopted by some of the surgeons as a cure for chronic diarrhoea, with success.

In contrast to the indescribable conditions which existed during the battle of Chateau Thierry, which was an emergency offensive on the part of the French and Americans, and for which no time had been given to sufficiently prepare, the battle of St. Mihiel, which was carefully planned, presented an organized front with sufficient water points developed. Here the Engineers had surveyed the area and located at proper places steri-labs and chloro-pumps, and from maps had ascertained the sources of water in the area behind the German lines, and even provided the equipment for immediate installation when the American troops had gained this ground, so that in the very rapid advance sterile water would be obtained.

Nevertheless when the battle broke, and the troops advanced their lines some 8 kilometers the first day, and ultimately reached positions 22 kilometers distant from the jump-off, a period of three days elapsed before potable water could be supplied from definite water points. During this time the Divisional Laboratory concentrated its effort on the work of determining the presence of free poisons in the water, and the selection of certain sources as satisfactory supplies for the use of the troops until the Engineers had time to bring up their equipment and establish water points. The Lyster Bags were used with considerable success, and although there were a number of cases of diarrhoea, the improvement was very marked as compared with the battle of Chateau Thierry. Likewise in the Argonne Forest, after the troops had advanced the battle line a considerable distance beyond "No Man's Land," there was a period of two or three days elapsing before the Engineers were able to supply potable water from definite water points. It can safely be said that the first three days of battle represent chaos in an organized effort to supply water from established sources.

The question immediately arises as to how this condition can be overcome, or, if not overcome, ameliorated during the initial stages of a great drive. The fact that the American people are the greatest water-drinking people on earth necessitates that each soldier be provided with more water than is now permitted with the small army canteen. Increasing the army canteen to twice its present size,

though it increases the weight the men must carry, would supply water enough to last two days.

The French discovered the necessity of this early in the war, for they used at that time a canteen containing one liter. At the first battle of the Marne the water or wine was soon consumed and during the days of retreat that followed, men in their raging thirst, drank from ditches at the roadside, and a few kilometers farther dropped out because of acute diarrhoea or dysentery, and in this condition were captured by the enemy. Seeing the importance of this, the French commanders immediately authorized the manufacture of a 2-liter canteen, and this was used with great satisfaction during the remainder of the war. It must be realized in this connection, however, that the French soldier was issued a wine ration daily rather than water, and the quantity of wine necessary to quench thirst is much less than water, so that the water-drinking American soldier was at a proportionately greater handicap in the hard conditions of an advance.

In addition to this, the regiment of Engineers assigned to each combat division should include in its personnel sufficient engineers familiar with water supply work to meet the exigencies arising. It is the opinion of the author that, by following these two recommendations, the terrible situation always found during the early stages of battle would be greatly relieved.

Even as this war was the most enormous war that has ever been fought by man, and its improvements in man-killing devices superior to those of any other war, so too have been developed in a like degree man-saving devices. The great scourge of the wars of all ages past was typhoid fever and its kindred malady para-typhoid. Whole armies have been decimated by these diseases, and bullets were never to be more feared. In most cases, these were water borne diseases and it was never found possible to eliminate them from the water nor to arrest their invasion of the human system. The discovery, however, of the typhoid and para-typhoid prophylaxis, together with the chlorine sterilization of drinking water, has laid low this terror, with the result that the American Army during this war has never been seriously affected by them. We have not as yet, however, found the means to prevent the entrance of the many low-grade organisms which caused the diarrhoea so prevalent in our major operations in France. No one of these could be actually said to be the causative organism, but all seemed to conspire to produce the

illness. There is, for this reason, no possibility of producing an artificial immunity to them. The diarrhoea was not a fatal disease except in rare cases, but yet it incapacitated so many men in the fighting line that it became a very dangerous enemy. The only way found to prevent this diarrhoea was the constant sterilization of the drinking water by one means or another.

To meet this situation and maintain a supply of drinking water in which the bacteria causing this very troublesome diarrhoea is eliminated, requires the services in each Division of an organization with a personnel trained in the control and purification of water supplies. During the recent emergency, in the hasty organization of our army, a field laboratory was assigned to each division for the purpose of caring for the investigation and control of water. Unfortunately, since the duties of this organization were not prescribed, it was not able to function in all instances with complete success. The primary function of the laboratory was the control of the water supply and the investigation of communicable diseases. It was unfortunate in many instances, however, that men were assigned as officers to these laboratories who knew nothing of the practical nature of water control and purification. The reason for this was, that these officers were for the most part men who were doctors of medicine, trained in the methods of clinical diagnosis and cure of disease but lacking the technical knowledge of water so necessary in this field of work.

It is now recognized that during the past decade the field of medicine has outgrown the bounds of the hospital and the clinic. Advances have been made so rapidly in all forms of science that the graduate of a medical school is not and can not be expected to have mastered all the ramifications of the science of medicine, such as advanced bacteriology, chemistry, the X-ray, sanitary engineering, public health administration and the control of water and milk supplies. There are highly skilled experts in each of these fields who do not possess the degree of M.D. and have very little necessity for it. This condition was seen rather tardily by the army in the emergency, but it was met as well as possible by the creation of a new corps, subordinate to the medical corps, which gathered to the commissioned personnel those men whose knowledge and skill would have been thrown away either as non-commissioned officers of the medical department, with no real power or authority, or squandered in the infantry.

The emergency is past, the victory is ours, and now the army has returned to its peace-time size. Our participation in the struggle was rich in experience, but it does not seem that the full benefit of this experience is being realized. The medical department has returned to almost its peace-time status, but yet no provision has been made for a future emergency by the inclusion in its organization of a separate and distinct corps of non-medical, scientific experts whose services proved so valuable during this war.

It is the purpose of the author in presenting this matter at this time, and before this organization, because of its importance to the army and the country, that effort be made to have legislation enacted providing for the organization of such a corps within the Medical Department of the United States Army.

RAINFALL AT MUSCATINE, IOWA[1]

By Wm. P. Molis[2]

This paper gives data of the rainfall in eastern Iowa covering a long period of years. The value of such data in determining the relation of precipitation to the floods in rivers and stream and the stored water in lakes is well known. The rainfall is the source of the water supplies of our communities, and long-time records of it are invaluable in estimating the quantity of water obtainable from a surface supply and in investigations of the quantity which exists as ground water. Such data are also valuable in studies of the relation between rainfall and floods. Few who have not experienced flood difficulties realize the danger which may arise if their pumping stations and machinery are situated on low lands exposed to overflow. A rain of one week or a cloudburst will suddenly swell the streams to such a height as to make quick work by the water department necessary in order to save the plant from being put out of commission.

In view of the special importance of rainfall records to water works this paper calls attention to the data which have been collected at Muscatine, as showing what can be obtained in other cities, to a greater or less degree, if the superintendent will make a point of searching for information about old records, which have been kept in a more or less complete form by residents of most cities. Such data should be compiled by the water department of each city as a sort of inventory of its stock that can be made more or less available for the consumers when fully developed.

The author has kept rainfall records personally for the last forty years and has collected such data from others in the city for previous years as far back as 1846. He thus has a rainfall record for the last seventy-three years which is very complete. Table 1 and figure 1 give the annual precipitation, including snow, for this entire period.

[1] Read before the annual meeting of the Iowa Section on April 16, 1919. Discussion of this paper is requested and should be sent to the Editor.

[2] Superintendent, Muscatine City Water Works, Muscatine, Iowa.

TABLE 1

Annual rainfall, including melted snow, at Muscatine, Iowa during seventy-three years; in inches

FIRST YEAR IN DECADE	YEAR IN DECADE									
	0	1	2	3	4	5	6	7	8	9
1840	—	—	—	—	—	—	34.55	28.50	39.62	59.16
1850	49.08	74.50	59.39	44.92	23.66	31.13	41.94	34.85	58.45	35.96
1860	25.10	44.23	53.16	28.83	32.77	34.21	32.86	34.24	40.91	43.36
1870	24.61	36.11	35.41	28.43	34.78	37.59	53.57	44.78	39.30	33.83
1880	36.78	45.66	46.67	41.12	45.49	39.34	34.22	28.30	38.89	33.49
1890	30.30	34.90	49.71	30.68	27.82	28.09	34.49	49.71	34.08	27.26
1900	32.30	24.50	47.57	33.68	28.22	32.59	29.51	34.26	38.91	37.62
1910	23.04	39.50	26.50	30.94	23.67	35.70	33.29	26.07	37.44	

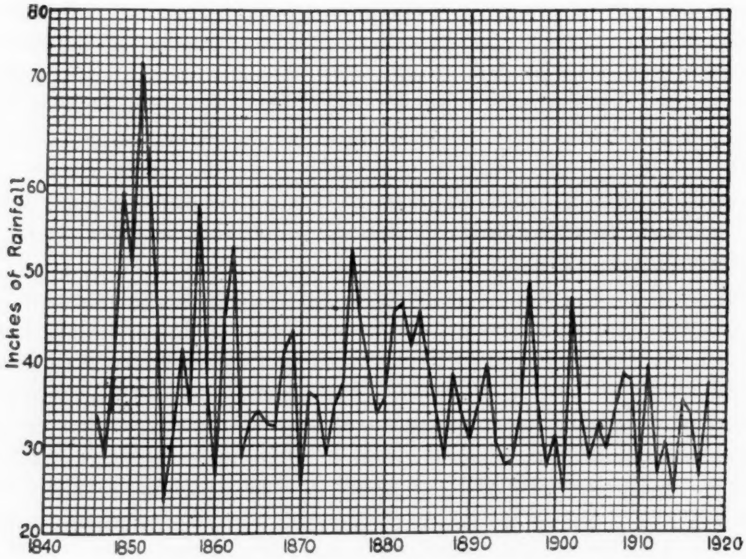

FIG. 1. ANNUAL RAINFALL, INCLUDING SNOW, AT MUSCATINE, IOWA

The total rainfall during all these years was 2,720.40 inches or 225.20 feet. The average was about 37 inches. The minimum for the whole period was 23.04 inches, in 1910, and the maximum was 74.50 inches, in 1851. This is a range of 51.06 inches or $2\frac{1}{4}$ times the minimum. Or the average, expressing the relation in another way, is about 14 inches above the minimum and $37\frac{1}{2}$ inches below the

TABLE 2

Total and average annual rainfall, including melted snow, by periods of ten years, at Muscatine, Iowa; in inches

PERIOD	TOTAL	ANNUAL AVERAGE	PERIOD	TOTAL	ANNUAL AVERAGE
1846–1855	444.51	44.45	1886–1895	336.40	33.64
1856–1865	389.50	38.95	1896–1905	344.40	34.44
1866–1875	346.30	34.63	1906–1915	318.95	31.89
1876–1885	425.54	42.55	*1916–1918	*96.30	32.10

* Three years only.

TABLE 3

Monthly rainfall, including snow, at Muscatine, Iowa, in 1905–1918 inclusive; in inches

	1905	1906	1907	1908	1909	1910	1911
January	0.93	2.35	3.77	1.11	2.19	1.73	1.38
February	1.37	2.78	0.26	2.07	2.30	0.74	3.88
March	2.20	2.72	1.65	2.77	1.58	0.36	0.95
April	3.41	1.75	2.21	2.35	5.46	2.40	3.45
May	3.20	3.49	4.04	5.97	3.35	4.24	2.65
June	4.36	3.56	4.21	4.05	4.43	2.62	2.33
July	4.59	1.86	7.97	4.25	3.63	2.94	4.33
August	3.36	2.32	5.16	8.35	2.61	3.17	3.11
September	1.43	2.67	2.37	2.73	1.96	2.80	8.58
October	4.49	1.75	1.09	1.98	1.68	0.66	2.48
November	2.28	2.34	0.89	2.78	5.53	0.42	4.32
December	0.97	1.74	0.64	0.50	2.90	0.96	2.02
Total	32.59	29.51	34.26	38.91	37.62	23.04	39.50

	1912	1913	1914	1915	1916	1917	1918
January	0.27	0.58	1.20	2.11	5.29	0.99	1.16
February	1.89	1.86	0.89	2.51	0.63	0.17	1.57
March	1.90	1.97	1.92	0.76	2.67	0.89	0.25
April	2.49	2.30	1.81	0.83	1.25	3.21	3.41
May	2.64	6.43	1.43	5.95	4.27	4.30	8.10
June	1.41	7.31	5.30	4.27	4.16	4.83	4.63
July	4.80	0.29	0.95	5.00	1.43	2.82	4.22
August	2.49	3.07	1.72	2.05	2.83	1.81	5.91
September	1.58	2.63	4.68	7.60	4.35	4.16	2.03
October	4.74	3.20	1.80	0.68	2.91	2.02	2.75
November	1.32	0.24	0.12	3.08	1.36	0.18	1.88
December	1.00	0.97	1.85	0.86	1.69	0.69	1.53
Total	26.50	30.94	23.67	35.70	33.29	26.07	37.44

maximum. This shows the relatively small influence on the long-time averages of rainfalls above about 40 inches annually, a fact that is also indicated in figure 1.

In studies of rainfall it is sometimes desirable to smooth out the effect of exceptional years by using the averages of ten-year periods instead of the annual records. These ten-year averages are given for the entire period of seventy-three years in table 2, which discloses the interesting fact that three of these ten-year averages exceeded the annual average of seventy-three years and four of these averages were below it.

It is becoming more common in certain investigations of rainfall to employ monthly averages, since these show the distribution of the

TABLE 4

Rainfalls, including snows, at Muscatine, Iowa, since 1903, amounting to or exceeding 1.50 inches in twenty-four hours

YEAR	DATE	INCHES	YEAR	DATE	INCHES	YEAR	DATE	INCHES	YEAR	DATE	INCHES
1904	Dec. 12	2.00	1907	July 10	2.10	1911	July 28	1.55	1916	Jan. 26	1.75
	Dec. 27	1.56		Aug. 15	1.85		Sept. 11	2.00		Mar. 26	1.95
1905	Jan. 6	1.50	1908	Aug. 11	3.15	1912	July 20	1.77		May 14	2.02
	June 9	2.57		Aug. 15	1.65	1913	May 1	1.94	1917	Sept. 7	1.50
	July 1	1.78		Aug. 28	2.47	1914	June 22	1.54	1918	May 23	2.00
	Oct. 16	2.77	1909	June 10	1.70		Sept. 5	2.20		July 6	2.35
1907	May 23	1.45		Aug. 27	1.90	1915	May 26	2.05		Aug. 17	1.80
	July 8	1.86		Nov. 7	1.54		Sept. 10	2.80	1919	Mar. 16	3.50

precipitation during the year. The records of this kind at Muscatine during the period 1905 to 1918 inclusive are given in table 3, which shows extraordinary ranges in some of the months. The maximum for any one month was 8.58 inches, in September, 1911, and the minimum was 0.12 inch, in November, 1914. The difference is 8.46 inches, or 70½ times the minimum.

If the records are separated into two thirty-year periods, 1846 to 1875 inclusive and 1876 to 1915 inclusive, it will be found that the annual average for the first period was 39.34 inches and for the second 36.88 inches, or 2.46 inches less. These figures are interesting as showing by comparison with those previously stated how the effect of time is to smooth out the great differences in the averages of short periods.

In studies of the effect of rainfall on the stages of rivers and lakes it is necessary to have a knowledge of storms of unusual severity. The severity of a storm is an essentially local matter in every way, for an exceptional downpour at Muscatine would be regarded as nothing but a brisk shower on the Canal Zone. For Muscatine purposes, it has been assumed that a rainfall or snowfall of 1.50 inches in twenty-four hours was sufficiently exceptional to deserve

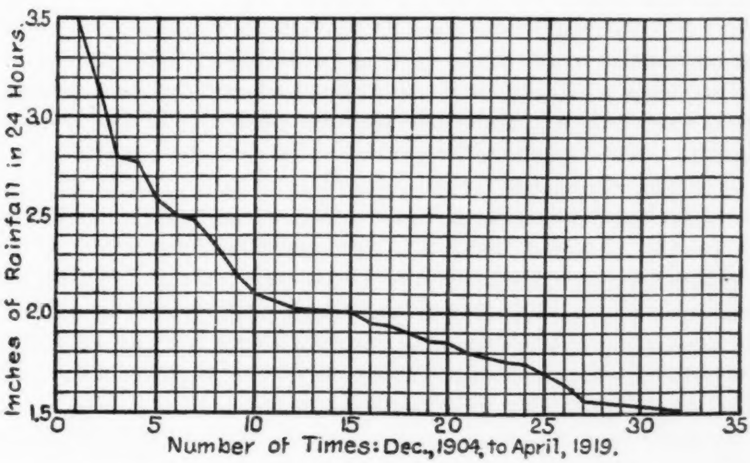

FIG. 2. FREQUENCY OF RAINFALLS OF 1.5 INCHES OR MORE IN 24 HOURS AT MUSCATINE, IOWA

special record. Accordingly table 4 has been prepared, giving a record of all such precipitations in the last fifteen years. From this table the curve given in figure 2 has been plotted, from which it is possible to estimate the probability of a rainfall of any intensity occurring at any time. For instance, a 2-inch fall occurs about once a year, and if none occurs during the first six months of a year a study of table 4 and figure 2 will show that it is prudent to expect a precipitation of 2 inches or more in twenty-four hours during the last half of the year, probably in July, August or September.

FLAT RATE VERSUS METERS[1]

By C. E. Abbott[2]

There has always been some controversy as to the relative merits of conducting water works systems on a flat-rate basis and an all-meter basis with conditions otherwise the same, and as to whether the benefits to be derived warrant the installation of the all-meter system. The owners and operators are practically unanimously in support of the meter system, while the consumers uniformly contend for the flat-rate basis; and this fact alone tends to show upon whose side the benefits of the meter system lie.

Of course, no criterion can be established for the entire country from statistics gathered in any one locality and, furthermore it would be foolish for any one man to undertake from his own experience to prescribe the best operating methods for localities other than his own and operating under conditions with which he is not familiar. The author has been manager of the Water Works System at Tuscaloosa, Alabama, for about eight years. During this time the plant there has been operated first upon a flat-rate basis and later upon a practically all-meter basis, and he is, therefore, in a position to give facts and figures, by a comparison of which the many advantages of the meter system can be easily seen. However, he certainly does not wish to be regarded in the light of trying to tell other managers and superintendents how to run their business, or to insinuate that he knows it all, or any more than any one else. But, having operated his plant under both systems and had opportunity to observe carefully the results of both operations, it has occurred to him that probably the figures covering these operations might be of interest to other operators who perhaps at this time find themselves under conditions similar to those at Tuscaloosa when the change from the flat-rate basis to the meter basis was contemplated.

[1] Read before the annual convention at Buffalo, June 13, 1919. Discussion of this paper is requested, and should be sent to the Editor.

[2] Manager of the Tuscaloosa, Ala., Water Works.

There are many advantages of the meter system over the flat-rate system that need no comparison to establish their validity One of the foremost of these is the great injustice to the consumers themselves in the flat-rate system. Upon this slack basis one consumer may pay a stipulated amount for his water—based probably upon the number of openings—and probably use 5000 cubic feet of water within a given time; while another consumer with the same number of openings and paying the same basic amount for his water could use 10,000 cubic feet of water within the same time and with no additional cost.

However, being a manager of a plant, of course the author is concerned chiefly with the operator's side of the matter, and it is the benefits and advantages to be derived by the operator himself that it is proposed to show in making a comparison of the statistics set out below representing the operation of this plant first upon a flat-rate basis and later upon a meter basis. Of course, the points of the greatest concern to the operator are, increasing the general efficiency of his plant, cutting down the amount of water to be pumped, cutting down the amount of fuel consumed—with the consequent decrease in operating expense—and increasing the revenue.

In 1911 the plant was operating upon a flat-rate basis. The installation of meters was begun in the fall of 1913 with the idea of metering the entire system, which was practically completed in 1915. Beginning with the year 1916 the plant was operating upon practically an all-meter basis. Therefore, by a comparison of the statistics covering the operations during these two years the effect of the installation of the meter system can be shown. By this comparison the author proposes to show how the amount of water pumped per day in 1911 under the flat-rate basis was decreased in 1916 under the meter basis by about 27 per cent, notwithstanding the fact that there was an increase in the number of consumers in 1916 of about 65 per cent, and how the amount of coal consumed in 1911 was decreased by about 63 per cent in 1916, and the operating cost decreased proportionately.

The general conditions under which the plant was operated in 1911, and the equipment, were as follows:

The power plant is situated upon the banks of the Warrior River, about 3 miles above the City of Tuscaloosa. The plant is situated upon an incline, the settling basin being above the plant and the

water flowing by gravity through slow sand filters to the clear-water basin below the plant. The water was pumped from this clear-water basin to a stand-pipe in the city, the tank having a capacity of 125,000 gallons and an elevation of 100 feet. The pumps were operated 24 hours a day, working against a pressure of 165 pounds at the plant. The actual equipment consisted of three 72 inch by 16 foot return tubular boilers; two horizontal, compound, non-condensing, Worthington pumps, alternating in operation weekly. The cylinders were: high pressure, 16 inches; low-pressure, 25 inches; water plungers, 11 inches; stroke, 15 inches; rated capacity 24 gallons per stroke. The water pumped in 1911 is figured on the delivery of these pumps, allowing 10 per cent for slippage.

The figures covering the operations during the year 1911 are as follows:

Number of consumers at end of 1911:	
Flat-rate	927
Meter	42
Amount of water pumped during entire year, gallons	317,335,980
Average amount of water pumped daily, gallons	869,413
Number of tons of coal used during year, tons	3,285
Cost of coal per ton	$2.00

The general conditions under which the plant was operated in 1916, and the equipment, were as follows:

The operating conditions in 1916 were the same as in 1911, with the exception that a new reservoir had been built within one-half mile of the power plant. It is 62 feet high and 75 feet in diameter, constructed of reinforced concrete. This reservoir was planned and built by Morris Knowles, of Pittsburgh. There was also a new high service pumping engine added; type, Myer; gear flywheel; high-pressure cylinder 14 inches; low-pressure cylinder, 30 inches; water plunger, $10\frac{1}{4}$ inches; stroke, 24 inches; condensing; rated capacity, 30 gallons per stroke; manufactured by Laidlaw-Dunn-Gordon Company. The amount of water pumped in 1916 is figured on the delivery of this pump, allowing 5 per cent for slippage. The number of pumping hours was reduced in 1916 to an average of ten hours per day.

The figures covering the operations during the year 1916 are as follows:

Number of consumers at end of 1916:	
Flat-rate	190
Meter	1,414
Amount of water pumped during entire year, gallons	230,779,985
Average amount of water pumped daily, gallons	632,274
Number of tons of coal used during the year, tons	1,215
Cost of coal per ton	$1.95

Comparison of the statistics for the two years 1911 and 1916

Total number of consumers in 1911	969
Total number of consumers in 1916	1,604
Numerical increase in number of consumers	635
Representing an increase of 65 per cent plus.	
Amount of water pumped during 1911, gallons	317,335,980
Amount of water pumped during 1916, gallons	230,779,985
Numerical decrease in gallons pumped	86,555,995
Representing a decrease of 27 per cent plus.	
Number of tons of coal used during 1911	3,285
Number of tons of coal used during 1916	1,215
Numerical decrease in number of tons	2,070
Representing a decrease of 63 per cent plus.	

All the above figures are taken from the records of the City Commission of Tuscaloosa, and can be verified upon inquiry.

From the standpoint of efficiency, and in order to check the operations of the plant, it is essential that the operator account for, so far as is possible, all the water that is pumped; and it is unquestionable that the meter system provides the best method for this. However, notwithstanding all the benefits derived from the employment of meters, even where the meter system is employed certain conditions arise in which it is not practicable to use meters. It will be noted that while employing the meter system almost entirely, there are still 190 consumers receiving water on a flat rate. This condition arises from the fact that these 190 consumers live outside the sewer zone and have each only one opening on the premises, and twenty meters placed on consumers under identically the same conditions show that 50 per cent of the minimum allowed under the flat rate is never reached.

With the meter system in operation during the year 1916 it was possible to account for 85.8 per cent of all the water pumped during the year. These figures would be higher but for the fact that there

was no way of accounting for the water used in fighting fires, and the amount used in street flushing, sprinking, etc., is purely an estimate based upon the capacity of the tank, and the estimate is in fact considerably below the amount of water actually used for these purposes. The figures in substantiation of this are as follows:

	gallons
Total meter reading for domestic consumers	114,186,477
Total meter reading for manufacturers, etc	58,144,425
Total meter reading for filter wash-water	9,552,660
Total meter reading for schools	2,920,460
Estimated amount used in street sprinkling, etc	11,182,000
Total amount of water accounted for by records	196,986,022
Total amount of water pumped during year	230,779,985
Water unaccounted for	33,793,963

Representing a percentage of only 14.2 of the total amount pumped unaccounted for.

SOCIETY AFFAIRS

THE ASSOCIATION'S OFFICES

Members of the Association who visit New York should not forget that the new offices of the organization are at their disposal. In order to reach No. 153 West 71st Street from the Grand Central Terminal several alternative routes may be taken. The visitor can take the 42d Street and Broadway surface cars to the corner of Broadway and 71st Street; there he should go to the right or east through 71st Street and he will find the offices on the left or north side of the street. Or he can take the uptown subway train at the Terminal and ride to 72d Street; there he goes south one block to 71st Street, turns to the left and finds the offices on the left or north side of the street. Or he can take the Harlem trains on the Sixth Avenue Elevated Railroad or any train on the Ninth Avenue Elevated Railroad to 72d Street; then go south one block on Columbus Avenue, turn to the right and the offices will be found on the right hand side of the street. Or he can take the Fifth Avenue Bus Line No. 5 to 71st Street, turn to the right on 71st Street and the office will be found on the left hand of the street. The means of reaching the offices from the Pennsylvania Terminal are practically the same, except that the surface cars do not pass this terminal.

The Secretary will be pleased to have members direct their mail to this office, and it will be forwarded from there to other addresses if mailing instructions are given. The publications of the Association are on file, and members can make the offices their headquarters while they are in the city. It is hoped they will take advantage of these quarters while they are in New York, so that the expenditure for rent may be of the maximum service to everybody connected with the Association.

COMMITTEE ON STANDARD SPECIFICATIONS FOR WATER METERS

President Davis has appointed the following committee to investigate the standardization of specifications for water meters: Robert J. Thomas, Lowell, Mass.; Dow R. Gwinn, Terre Haute, Ind.; Caleb M. Saville, Hartford, Conn.; Seth M. Van Loan, Philadelphia, Pa.

CONVENTION PAPERS

Members who contemplate offering papers to the Publication Committee for presentation at the annual convention at Montreal are urged to take up the matter at once with the chairman of the Committee, W. W. Brush, Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, Municipal Building, New York. The program must be definitely adopted very soon. It should be well balanced so as to interest everybody engaged in any branch of water supply. Such a balance is always rather difficult to obtain, and particularly so when it is desirable, as in this case, to take advantage of local conditions of the place of meeting in order to discuss the water works practice of that district.

Members who do not contemplate offering papers but desire to have some subject presented for discussion or a paper prepared on some topic, are requested to send their views to Mr. Brush immediately. The Publication Committee will appreciate all suggestions regarding convention matters which are sent to it now, when it is possible to give them careful consideration and adopt those which can be fitted into the program. Suggestions made after the program has been adopted and the papers on it are being prepared will be too late to be of the help that those received now afford.

THE ELECTROLYSIS FUND

At the Buffalo convention the representatives of the Association on the American Electrolysis Committee reported that it was very desirable for the Association to engage a technical specialist to represent the Association in connection with investigations of electrolysis by the U. S. Bureau of Standards. The report on this subject will be found in the JOURNAL for September, 1919, page 588. The Association voted to receive the report, to continue the Committee and to authorize the Executive Committee to fill the vacancy on the Committee and to take under advisement the appointment of an expert to assist the Committee. Acting under this authority the Executive Committee appointed Nicholas S. Hill, Jr., to act with the former members, Alfred D. Flinn and Edward E. Minor, and authorized this Committee to raise such funds by private solicitation as it considered necessary for carrying on the work; provided that the Secretary of the Association be kept informed concerning

the progress of the work, the sources from which the funds are derived and their amounts and disbursements.

The members were duly notified of this action in a circular issued by the Secretary. About $3000 is needed for retaining the services of this expert and for his expenses, and the other incidentals authorized by the Association. On December 16 the Association's Treasurer reported that he had received 36 subscriptions amounting to a total of $2135, about 71 per cent of the sum desired.

It has been suggested that the water departments of many cities which would gladly coöperate in this investigation cannot do so on account of absence of legal right to subscribe to committee investigations. It would seem that this hindrance is more theoretical than actual in this case, because it is probable that a city where electrolysis has caused trouble will not be debarred by any legal obstacle from assisting in paying for professional services in searching for remedies for electrolysis. It would seem feasible, therefore, in such cases to ask for authority to join with other water departments in retaining the services of an expert to investigate electrolysis, to make out the check to this expert, and to send it to him through the Association's Treasurer so that the latter may have a record of the matter. There are so many cities in which electrolysis is causing serious damage that there should be little difficulty in securing the total subscription needed to enable the Association to coöperate with the other organizations which are participating in this work.

IOWA SECTION

The fifth annual meeting of the Iowa Section was held at Mason City, Iowa, on October 22 and 23, with the Section chairman, W. A. Judd, presiding. A feature of the program which is not customary was the opening of informal discussions at the first session, immediately after the addresses of welcome by Mayor N. C. Ketchell and Senator A. L. Rule and a reply by the vice chairman of the Section, George E. Shoemaker. These informal or round table discussions are a regular feature of the meetings of some of the sections, and attention is called to them on account of the discussions at meetings of other sections on the best method of bringing to the attention of the members generally topics of special interest to those proposing them.

The following topics were introduced in this way at the meeting at Mason City: "Hydrant and Valve Inspection," discussed by W. A. Judd, G. E. Shoemaker, S. L. Etnyre, Peter Kern, F. D. H. Lawlor, Philip Carlin and several guests; "Future Water Rates," discussed by G. E. Shoemaker, Philip Carlin, W. A. Judd, Robert B. Wallace, J. Christopher Jensen, R. H. Holbrook and several guests; "Air in Water Mains," discussed by William Molis, Philip Carlin, F. D. H. Lawlor, W. A. Judd and S. L. Etnyre.

The papers presented at the five sessions of the annual meeting were as follows:

"A Water Supply of the S. O. S.," by Jack J. Hinman, Jr., recently Captain, Sanitary Corps, Sanitary Inspector of Water, American Embarkation Center, Le Mans, Sarthe, France.

"Notes on Experiences with Presumptive and Confirmatory Tests for B. coli in the A. E. F.," by Max Levine, recently Captain, Sanitary Corps, Central Medical Department Laboratory, Advance Section, Dijon, Cote d'Or, France.

"Some Water Supply Problems of the A. E. F.," by Edward Bartow, recently Lieutenant Colonel, Sanitary Corps, in charge water supply laboratories, A. E. F.

"The Water Supply Problem in a Combat Division," by Lucius A. Fritze, recently Captain, Sanitary Corps, water supply officer of the Rainbow Division and the Army of Occupation.

"Flushing and Cleaning of Water Mains," by William Molis; discussed by Geo. T. Prince, Homer V. Knouse, Philip Carlin, W. A. Judd and guests.

"The Rural Water Supply an Integral Part of the Municipal Supply," by Dr. E. G. Birge; discussed by William Molis, Robert B. Wallace, John H. Dunlap, Edward Bartow, G. E. Shoemaker, W. A. Judd, H. H. Wagenhals, and Max Levine.

"An Experience with a Broken 24-Inch Main," by S. I. Etnyre; discussed by F. D. H. Lawlor, William Molis, Geo. T. Prince, and W. A. Judd.

"Concrete in Water Works Construction," by A. C. Irwin.

"Final Report of the Committee on Sanitary Drinking Fountains," presented by the chairman, J. H. Dunlap, accepted by the Section, and the committee discharged.

"A History of the Mason City Water Supply," by A. R. Sales.

"Material Prices," by C. B. Sherman.

"Air Lift Pump," by Charles J. Deem.

The meeting adopted resolutions of thanks for courtesies received, to the authors of papers and to Professor Dunlap for his services as acting secretary-treasurer, and the following resolutions, to be sent to all interested persons:

No. 1

WHEREAS, We are informed that the present plans for the reorganization of the Army do not include provisions for the scientists, chemists, bacteriologists, biologists, physicists, etc. formerly connected with the Sanitary Corps, and

WHEREAS, To our certain knowledge these men performed valuable service during the recent emergency.

Be It Resolved, That the Iowa Section of the American Water Works Association in annual convention now assembled through its secretary, request the Senators and Representatives in the State of Iowa to use their influence in every possible manner for the provision of a corps in the U. S. Army, whether independent or under some existing Department, in which these technically trained non-medical scientists may serve; and the creation of a division of Reserve Officers corresponding thereto.

No. 2

Resolved, It is our privilege to again testify to the value of the Laboratories of the State Board of Health at Iowa City.

That our members be requested to use their influence to educate the public on the importance of this work and to remind the members of the State Legislature that if they would safeguard the public health, the work of this laboratory should be continued and extended.

No. 3

Resolved, That a committee of five members, including the Chairman and Secretary, be appointed by the Directors to prepare and urge the passage of legislation to provide a frontage tax for the extensions of water mains in cities and also legislation to do away with the injustice that now exists in certain cities where no tax for fire protection is levied and where water consumers have to pay for the fire protection of property owners who do not use city water.

Resolved, That it should be obligatory on cities to levy this tax.

No. 4

Resolved, That recognizing the unprecedented rise in the cost of labor and supplies necessary in the furnishing of water to the cities of Iowa, the Iowa Section of the American Water Works Association recommends that the

necessary advance in water rates be made rather than allow the plants to depreciate and their efficiency decrease, thus endangering the lives and property of the consumers.

A feature of the meeting to which special attention is called occurred at the close of a luncheon served in the rooms of the Chamber of Commerce by the Mason City Water Department. The board of directors of the chamber took advantage of the presence of a large gathering of experienced water works managers to discuss the relative advantages of placing the control of water departments in the hands of special water commissions, with city councils or with city commissioners.

The Section not only enjoyed the hospitality of the Mason City Water Department, as just mentioned, but also of the Chamber of Commerce, which furnished a meeting place and an excursion to the points of interest near the city as well as complimentary dinner.

It was voted to request the parent body, the American Water Works Association, to permit the Section to extend its membership to members of the Association in Nebraska, South Dakota and adjoining states who have no sections they can join.

The following officers were elected for the next year: chairman, George E. Shoemaker, Waterloo; vice-chairman, Frank D. H. Lawlor, Burlington; directors, Robert B. Wallace, Council Bluffs, and R. B. Roos, Dubuque.

CENTRAL STATES SECTIONS

A meeting was held at Erie, Pa., on September 24 and 25, 1919, at which papers were presented by Joseph W. Ellms on "Ozone as a Disinfectant in Water Purification" and by Maurice R. Scharff on "Water Supply Systems of Camp McClellan, Ala." Both of these papers are published elsewhere in this issue of the JOURNAL. There was also informal discussion of various topics proposed through a question-box. The officers elected for the next year were: Chairman, John N. Chester, Pittsburgh, Pa.; vice-chairman, G. C. Gensheimer, Erie, Pa.; secretary, R. P. Bricker, Shelby, Ohio; trustees, J. C. Beardsley, Cleveland, Ohio, for two years, and C. W. Wiles, Delaware, Ohio, for three years.

NEW YORK SECTION[1]

At a meeting at the Hotel McAlpin on October 22 Lieut.-Col. John P. Hogan, Deputy Chief, Topographical Section, General Staff, A. E. F., described the work done in France by the 29th Engineers, including map making from surveys and air-plane photographs, map printing and distribution, establishment of triangulation and traverse control for the direction of artillery fire. Colonel Hogan stated that, as a result of the experience gained in France, he believed photography from air planes to afford the least expensive method of conducting topographical surveys under certain conditions.

The latter part of the session was devoted to a discussion of methods of making both the Association and the New York Section more popular and helpful. The general trend of the discussion was that every endeavor should be made to develop subjects of interest to the superintendents of the smaller water-works, not to the exclusion of papers and discussions of topics of technical and administrative affairs arising only in large cities, but supplementary to such papers. If the Association is to develop into an organization of real influence, the general trend of the discussion ran, it must represent impartially the small and the large plants, the superintendent, engineer, chemist, bacteriologist, and financial manager. Particular stress was laid by several speakers on the need of a very careful study of the expenditures of the Association's income, in order to ascertain clearly what changes, if any, will increase the service the Association is giving the members.

ADDITIONS TO THE MEMBERSHIP

Active Members.

Edward S. Adams, District Manager, Dravo-Doyle Company, Cleveland, Ohio.

Frank H. Alpers, Superintendent Water Company, Cimarron, New Mexico.

Clarence M. Baker, State Board of Health, Madison, Wisconsin.

[1] The New York Section will hold its next meeting on February 18, 1920. All members in the city on that date are invited to attend. Information regarding the place and hour of the meeting can be obtained from the Secretary's office.

Richard Belcher, President Water Company, Marysville, California.

Edmund B. Besselievre, Germantown, Pa.

George W. Bierbauer, President Brookside Water Company, 401 Mining Exchange Building, Colorado Springs, Colorado.

William P. Born, Civil Engineer, Reading, Pennsylvania.

S. Hull Bowers, Superintendent Water Works, Horseheads, New York.

Abraham M. Bowman, Superintendent Public Utilities, Elmira, Ont., Canada.

Fred Bremeir, Director Division of Utilities, Board of Railroad Commissioners, Bismarck, N. D.

J. S. Buzby, Civil Engineer, Box 310, Burlington, New Jersey.

Richard D. Chase, Civil Engineer, New Bedford, Massachusetts.

Leland Chivvis, Engineer in Charge Distribution Section, 312 City Hall, St. Louis, Missouri.

C. H. Christensen, Manager Light & Water Company, Missoula, Montana.

Charles R. Claflin, Superintendent Water Company, Rennselaer, New York.

Bernard S. Cohen, Montclair Water Co., Little Falls, N. J.

J. J. Davenport, President Water Company, Sturgis, South Dakota.

W. H. Dechant, Civil Engineer, Reading, Pennsylvania.

C. L. DeMott, City Engineer, Lynchburg, Virginia.

John C. Diggs, Sanitary Engineer, State Board of Health, 54 Kealing Avenue, Indianapolis, Indiana.

John F. Druar, Consulting Engineer, St. Paul, Minn.

Wm. Cary Dunn, Chemist, Cristobal, Canal Zone.

Joseph W. Ellms, Consulting Engineer, Lakewood, Cleveland, Ohio.

Frank Emerson, City Engineer and Superintendent Water Works, Peabody, Mass.

H. L. Farrar, District Manager, Murphysboro Water Works & Electric & Gas Lighting Company, Murphysboro, Ill.

John B. Ferguson, Civil Engineer, Hagerstown, Md.

George E. Fisher, Fire Protection Engineer, 31 Milk Street, Boston, Massachusetts.

P. E. French, Mechanical Engineer, City Water Works, 420 Mesa Avenue, El Paso, Texas.

Farley Gannett, Consulting Engineer, Harrisburg, Pennsylvania.

Norman P. Gerhard, Civil Engineer, New York, New York.

Jesse K. Giesey, Civil Engineer, Fuller & McClintock, 170 Broadway, New York, N. Y.

Henry Goosen, Fairfield Water Works, Fairfield, Cal.

George A. Graham, Civil Engineer, Jacksonville, Fla.

W. C. Gray, Councilman, City Building, Sioux City, Iowa.

Tom L. Green, Consulting Engineer, Miami, Okla.

Harrison Gunning, Sanitary Engineer, Ancon, Canal Zone.

Edwin Hancock, Consulting Engineer, Chicago, Ill.

Harold Thomas Harill, Assistant Engineer, Department of Water Supply, Gas & Electricity, 51 North Street, Mt. Vernon, N. Y.

John E. Hasbrouck, Assistant Engineer, Department of Engineering, 52 City Hall, Rochester, N. Y.

Carl F. Hechmer, Deputy Engineer, Washington Suburban Sanitary District, Baltimore, Md.

Charles A. Holden, Civil Engineer, Hanover, N. H.

J. F. Horn, President Water Company, Vandergrift, Pa.

Harry E. Jordan, Sanitary Engineer, Indianapolis Water Company, Indianapolis, Ind.

H. O. Keerl, Civil Engineer, Clear Lake, Iowa.

R. B. Kendig, Manager Water Company, Punxsutawney, Pa.

Carl F. Klapp, Superintendent Water Works, Everett, Wash.

W. H. Lawrence, Superintendent Water Works, Kalispell, Mont.

Leonardo Lira, Chief Engineer of Inspection, Water Works, Sasilla 492, Santiago, Cuba.

Wm. B. McCaleb, General Superintendent Water Companies, Pennsylvania Railroad, 922 Commercial Trust Building, Philadelphia, Pa.

Henry A. Mentz, Assistant Engineer, Municipal Engineering Department, Magnolia, Miss.

J. R. Miller, Superintendent Jerome Water Works Company, Ltd., Jerome, Idaho.

John A. Moore, Manager Warwood Water & Light Company, Warwood, Wheeling, W. Va.

Arthur L. Mullergren, Consulting Engineer, Kansas City, Mo.

D. J. Nelson, Superintendent Water Works, North Collins, N. Y.

William A. Nial,, Superintendent Water Works, Troy, N. Y.

Henry Newhall, Superintendent Water Works, Danvers, Mass.

Paul A. Norcross, Consulting Engineer, Atlanta, Ga.

Eliot B. Norton, Superintendent Water Works, Cambridge, N. Y.

L. H. Ohliger, Superintendent Water Works, Canton, Ohio.

Howard J. Pardee, Engineering Department, Wallace & Tiernan, Chicago, Illinois.

G. A. Readshaw, Water Works, Sharon, Pennsylvania.

W. Blaine Redfern, Consulting Engineer, Toronto, Canada.

John Ryle, Assistant Engineer, Passaic Water Company, Paterson, N. J.

J. S. Schwartz, Constructing Engineer, Colorado Springs, Colorado.

Francis J. Seery, Professor Hydraulic Engineering, Cornell University, Ithaca, New York.

G. B. Shawver, Superintendent Water Works, Springfield, Tennessee.

C. T. Shepard, Superintendent Department of Public Service, Walnut and Sixth Streets, Niagara Falls, New York.

Joseph W. Soplin, Superintendent Water & Light Company, Princeton, Indiana.

C. A. Spencer, Superintendent Mountain Water Supply Company, 208 Couler Building, Greensburg, Pennsylvania.

Edwin M. Stanton, Chemist and Bacteriologist in Charge State Public Health Laboratories, Bismarck, North Dakota.

D. R. Stephen, Superintendent Water & Light Works, St. Mary's, Ontario, Canada.

Fred O. Stevens, Engineer and Superintendent, Water Works, East Weymouth, Massachusetts.

John W. Storrs, Civil Engineer, Public Service Commission, Concord, New Hampshire.

Frank Stone Tainter, Consulting Engineer, Far Hills, New Jersey.

Charles W. Tarr, Assistant Engineer, Morris Knowles, Inc., Pittsburgh, Pa.

John T. Taylor, General Manager, Beaver Falls Water Company, Beaver Falls, Pennsylvania.

Martin Thorsen, Field Engineer, Wallace & Tiernan Co., New York. N. Y.

A. L. Underwood, Superintendent Water Works, 148 North Pickering Avenue, Whittier, California.

Wm. James Walker, Secretary Kingston General Commission, Kingston, Jamaica, B. W. I.

Richard F. Wagner, Assistant Engineer Filtration Plant, Lynchburg, Virginia.

Donald T. Warner, President Pakeville Water Company, Salisbury, Connecticut.

George P. Wartchow, Superintendent Water Works, 815 Valley Street, Minot, North Dakota.

Norman McLeod Ramsey Wilson, Chief Engineer Water Commission, Brantford, Ont.

Wm. Wilson, Civil Engineer, Youngstown, O.

Corporate Members

Bel Air Water & Light Company of Harford County, Bel Air, Maryland.

Conservative Water Company, Los Angeles, California.

Green Bay Water Company, Green Bay, Wisconsin.

Associate Member

Hill Pump Valve Company, 2307 Archer Avenue, Chicago, Illinois.

DEATHS

F. P. Heller, Superintendent Rosemont Springs Water Company, Reading, Pennsylvania; elected Member May 12, 1908; died October 29, 1919.

Douglas A. Brown, official stenographer of the Association for more than twenty years, died November 12, 1919, at Cincinnati; although not a member of the Association he was personally known to a large number of the members through his long connection with its work and his able and active services for its advancement in every way in which he came into touch with its activities.